A STUDY ON THE HABITAT USE AND FOOD HABITS OF SWAMP DEER (*Cervus duvauceli duvauceli*) IN JHILMIL JHEEL CONSERVATION RESERVE, HARIDWAR FOREST DIVISION, UTTARAKHAND

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"Be an opener of doors for such as come after thee."

- Ralph Waldo Emerson

Dedicated to my Parents

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A study on the habitat use and food habits of Swamp Deer (*Cervus duvauceli duvauceli*) in Jhilmil Jheel Conservation Reserve, Haridwar Forest Division, Uttarakhand

Summary

Habitat use and food habits of the swamp deer (*Cervus duvauceli duvauceli)* were studied in and around Jhilmil Jheel Conservation Reserve (JJCR), Uttarakhand, during June 2006 and June 2008. This population of swamp deer was recently rediscovered in the state and warranted an ecological study and conservation initiative because the habitat around this study area is heavily fragmented due to expansion of agriculture, habitation and various other land use practices. Therefore, this study was initiated. The major objectives were:

i. To study seasonal variation in habitat use pattern and food habits,
ii. Activity pattern,
iii. Population structure and habitat condition, and
iv. Identify threats and suggest conservation measures

The JJCR is a saucer shaped wetland located between Haridwar – Najibabad highway and the River Ganges in Chidiyapur Forest Range of Haridwar Forest Division, Uttarakhand. The study area is located at the junction of the Bhabhar and Terai formations representing a unique and species rich ecosystem which encompasses spectacular landscape and mosaic of short and tall grasslands, tropical mixed moist deciduous forests and secondary scrub.

Swamp deer were observed from the vantage points using 40X spotting scope and 8X40 binoculars to record data on habitat utilization, activity pattern and population structure. Habitat availability and utilization were studies using Marcum-Loftsgaarden Analysis. In addition, relative abundance of swamp deer pellets were quantified in various areas to get an

idea of relative use of habitat. Food preference was studied using feeding quadrat method. Forage availability was measured through harvest method. Five transects (one in each habitat) were laid and vegetation sampling was carried out on the either side of the transect. Threats to species and habitat were assessed during the general survey of the area and by questionnaire survey.

The study reveals that swamp deer in JJCR prefer areas high in hydrophyte cover i.e., *Typha elephantina* and *T. angustifolia* which meet various cover requirements and avoid areas high in grass cover. They avoided open short grasslands possibly due to absence of hiding cover. Dense thickets of *Phragmites karka* were avoided during all seasons, possibly due to impenetrability, poor visibility, predation risk, and deeper water bodies. During rainy season (July-September) swamp deer preferred dense hiding/fawning cover while most of feeding takes place among *Typha* patches. Winter forms the rutting period for swamp deer, and cleared patches in *Typha* dominated areas which serve various purposes viz., sparring, basking, and foraging grounds. In summers sedge meadows are preferred for feeding, resting, wallowing, and drinking water while *Typha* patches are preferred for feeding, resting, and thermal cover.

The overall diet pf swamp deer consisted mainly of herbs (terrestrial and aquatic) and graminoids. The proportion of graminoids in the diet was lowest during winter while consumption of herbaceous plants (primarily aquatic) was maximum during summer. Plants of the family Poaceae together with Cyperaceae form the major food of swamp deer here. In the protected areas studied earlier the swamp deer habitat was dominated by grasses and hence they were reported to be almost exclusive grazers by Schaller (1967) and others. Its diet was also occasionally supplemented with aquatic plants and fruits of *Zizyphus.* In contrast, at Jhilmil the area also has equal presence of other plant types viz. sedges, herbs and aquatic species. This resulted in polyphagous feeding habit of species here. Mixed feeders though, they commonly concentrated on grasses during high rainfall periods and high rate of grass growth.

The daily activity pattern of swamp deer was of polyphase where feeding was mixed with lying and walking. Feeding itself showed a polymodal pattern with peaks found in different time periods. Swamp deer did not exhibit strong bimodal peaks in activity at dawn and dusk unlike the observations made by earlier workers elsewhere. These bimodal peaks are influenced by anthropogenic factors which are stronger at Jhilmil Jheel, which is close to a village (Tatwala). Hence, the swamp deer get into peak of activities before dawn and after dusk.

Largest herds (13) and highest male to female ratio (145) were observed during summer when deer congregate. In contrast to observations of authors in past, smallest herds were reported in monsoon instead of winter, the reason being poor sighting on account of dense vegetation cover. In monsoon fawning affect the group structure. Adult females tend to separate from the herds prior to giving birth. The highest degree of stability in group size and composition was noted during monsoon when food was abundant and daily movements at minimum. In winters, the fawn to female ratio was maximum (59), as fawning was over by this time and fawns were big enough to follow the mothers.

The grasslands dominated by *Imperata cylindrica* and Vetiveria *zizanioides* witnessed low abundance of swamp deer throughout the year. The reason was extremely heavy livestock grazing pressure and human presence. On contrast this plant species association was heavily utilized by swamp deer throughout the year and specifically in summer season in Dudhwa Tiger Reserve (Qureshi et al 1995).

Habitat evaluation of various potential (but fragmented) habitat blocks in Jhilmil Jheel Conservation Reserve area and surrounding Banganga wetland revealed that they bear a close resemblance with the prime swamp deer habitat both in terms of structure and composition of key habitat variables. This supports my suggestion of habitat expansion by way of including these potential habitat blocks during the course.

The swamp deer conservation requires a multitude of measures like restriction on livestock grazing and human movement in and around prime swamp deer habitat, regular patrolling by staff, awareness among villagers regarding wildlife conservation and providing them incentives and alternate livelihood options.

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Chapter 1

Introduction

CHAPTER 1
INTRODUCTION

1.1 The background

Most threatened species of deer occur in isolated and fragmented populations where anthropogenic pressures such as livestock grazing, encroachment and collection of grass and fuelwood are prevalent (Holloway 1975). Many of these species are on the verge of extinction and yet there is hardly any information on their ecology which is essential for formulation of long-term conservation measures. Recent (Sinha, S.P. *pers. comm.*) discovery of a small population (150) of swamp deer or barasingha (*Cervus duvauceli duvauceli*) in an isolated '*terai'* wetland of Uttarakhand (UK) brought forth the realization of an ecological study on this population. Descriptions on Barasingha have appeared sporadically in hunting literature of the last century. Blanford (1888-91) was the first to give an account of the distribution of the species. Brander (1923) presented more information on the Barasingha and made a distinction between the Barasingha in northern India and those in central India. Ellerman and Morrison-Scott (1951) subsequently distinguished two subspecies: *Cervus duvauceli duvauceli* Cuvier 1823 and *Cervus duvauceli branderi* Pocock 1943. Later, Groves (1982) distinguished the northeast race as new sub-species and named as *C. d. ranjitsinhii.* Now three subspecies of swamp deer are known to occur in India namely *Cervus. d. duvauceli* distributed in northern India, *Cervus. d. branderi* distributed in Kanha National Park in central India and *Cervus. d. ranjitsinhii* distributed in Assam. Preferred habitats of the swamp deer are marshes and grassland (Sankaran 1990). Swamp deer were once abundant throughout the tall wet grasslands of the North Indian Terai. The *Terai* area is characterized by fine alluvium with high water table dominated by a mosaic of hygrophilous grasslands and sal (*Shorea robusta*) dominated Tropical Moist Deciduous forests (Champion and Seth, 1968). Terai lies south of *Bhabar* tract which in turn lies south of Himalayan foot-hills. These three strata are in the form of narrow strips running parallel to the main Himalaya and there is a continuum of forests and wildlife populations across these zones. The Shivaliks, which

run along the base of the Himalaya, are an uplifted ridge system formed from the debris brought down from the main Himalaya. The coarse material brought down by the Himalayan rivers is deposited immediately along the foothills to form a pebbly-bouldery layer referred to as the *bhabar*, while the finer sediments or clay is carried further to form the *terai*. The *bhabar* is characterized by low water table as the deposits are bouldery and porous and all but the major rivers and streams disappear into the ground on emerging from the hills. The streams reappear along the *terai*, which has fine alluvial soil resulting in high water table. It is listed among the globally important 200 ecoregions for its unique large mammal assemblage. Most charismatic faunal species of *Terai* landscape include Great one horned rhinoceros (*Rhinoceros unicornis*), swamp deer (*Cervus duvauceli duvauceli*), hog deer (*Axis porcinus*), tiger (*Panthera tigris*), Asian elephant (*Elephus maximus*), hispid hare (*Caprolagus hispidus*), and Bengal florican (*Houbaropsis bengalensis*) and swamp francolin (*Francolinus gularis*). The natural vegetation in the Terai area comprises moist deciduous forests, scrub Savannah, and alluvial grasslands. The typical tree species in the forest are *Shorea robusta*, *Dalbergia sissoo*, *Terminalia tomentosa*, and *Acacia catechu* with other associated tree species such as *Butea monosperma*, *Bombax ceiba*, *Aegle marmelos*, *Terminalia alata*, *Adina cordifolia*, *Syzygium cumini*, *Mallotus philippensis*, *Lagerstroemia parviflora* etc. Common grasses in the area are *Themeda arundinacea*, *Saccharum spontaneum*, *Phragmites karka*, *Vertiveria zizanioides,* and several others (Johnsingh et al., 2004).

The ruthless destruction of terai ecosystem for agriculture and human settlements has led to large-scale fragmentation, shrinkage, and degradation of these unique habitats (Sankaran 1990). Simultaneously, the population of mammalian and avian species of this area witnessed serious decline in their abundance and distribution.

India’s past forestry practices have often considered grasslands as "wastelands". The resultant plantation of exotics and other indigenous tree species in grasslands has converted several grassland habitats into woodland (Rahmani *et al*. 1988). The distribution range of swamp deer was reduced

considerably due to habitat destruction and over hunting and at the turn of the 20th century the species survived in swampy areas from upper Assam extending to the Sunderbans in the east to the Indo-Gangetic plains in the west and southward up to eastern Maharashtra (Jerdon 1874, Bhadian 1934, Prater 1980, Brander 1982). The trend in range reduction continued and Schaller (1967) reported swamp deer from 28 localities only, of which five were in southern Nepal and the rest were in the Indian states of Uttar Pradesh (U.P.), Assam, West Bengal, and Madhya Pradesh.

The status of subspecies of northern Barasingha, *Cervus. d. duvauceli* was first assessed by Schaller (1967), who reported the presence of this subspecies from 11 localities in northern India. Later, Holloway (1977) reviewed the status and found Barasingha surviving in four localities out of 11 localities reported by Schaller (1967). The four localities were Pilibhit, north Kheri, south Kheri, and Bahraich. At present *duvauceli* is restricted to Jhilmil Jheel Conservation Reserve and Banganga Wetland (Uttarakhand), Hastinapur Sanctuary, Bijnor Forest Division, Pilibhit Forest Division, Kishanpur Sanctuary, Dudhwa National Park and Katerniaghat Sanctuary (U.P.) and Sukla Phanta Wildlife Reserve and Karnali Bardia Reserve in Nepal (Table 1.1).

1.2 Significance of the study

Ecological studies on the human interspersed Terai landscape are rather scanty. Most of the areas adjoining the course of major river systems viz., Ganges and Yamuna have remained neglected in the past due to hostile climatic conditions and frequent changes in the river courses. Similarly, typical faunal species of Terai viz., swamp deer, and hog deer have been studied largely within well protected areas of Nepal and eastern parts of Terai. The study area, Jhilmil Jheel in Haridwar Forest Division is a remnant *Terai* habitat which forms the western most part of *Terai* landscape in India. Considering the conservation significance of remnant terai habitat and endangered swamp deer an area of 37.8 km^2 was notified as a Conservation Reserve (Anonymous, 2005). Jhilmil Jheel represents a habitat island that serves as a

refuge for endangered swamp deer and associated floral and faunal species typical of terai belt. However, much of the habitat around Jhilmil Tal is now fragmented and degraded. Therefore, this study was taken up on the habitat use pattern and food habits of a swamp deer population in its north-western distribution range which would be complimenting the existing information on the species and its habitat and also would be of much conservation significance. It is hoped that this study would generate ecological information on the species to evolve a habitat management plan whereby the emphasis will be placed on habitat improvement for all parts of life for swamp deer. The Conservation Reserve Programme will go a long way towards enhancing and preserving the wetland and grassland so vital to swamp deer.

1.3 Swamp Deer

1.3.1 Systematic position and general characteristics

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Artiodactyla
Family:	Cervidae
Genus:	*Cervus*
Species:	***C. duvauceli***

Note: Recently (2005) the generic name *Rucervus* has been followed for this taxa and a graphical correction has been made in the species name which has been changed from “duvauceli” to “duvaucelii”. This new name is being followed by IUCN (version 2009.1). But due to lack of information on taxonomy of this taxa, previous name, i.e., *Cervus duvauceli* has been used in this thesis.

The swamp deer is endemic to the Indian subcontinent. The adults measure upto 180 cm in length, 119-135 cm in shoulder height. The adult stags weigh 170-280 kg and hinds upto 130-145 kg (Schaller 1967, Prater 1972, Gopal 1995). The coat is generally brown in colour, with males being darker than females. During winter the thick brownish coat is developed which is shed on the onset of summer. The summer pelage is reddish brown in

colour. The under parts, including the underside of the tail, are whitish. There is a dark dorsal stripe, on each side of which may be a row of faint spots (Dunbar-Brander 1927, Prater 1971). The antlers are worn only by males, and have twelve or more points thus the name Barasingha. The antler grows up to one meter in length, the largest measured was 104 cms long (Schaller 1967).

1.3.2 Ecology

The group sizes are smaller in *branderi* in comparison to *duvauceli* and *ranjitsinhii* due to small population and difference in grassland composition, structure, and habitat management regime (Schaller 1967, Martin 1977, Schaff 1978, Qureshi et al. 1995). The low male: female ratio is attributed to selective predation and poaching. The barasingha mortality is largely by predation, flooding (*duvauceli* and *ranjitsinhii*), and poaching. Tiger is a major predator of barasingha; there are anecdotal information and reports of kills by leopards and wild dogs. Jackal predation on fawns and yearlings has been reported by Singh (1985) and Schaff (1978). The frequency of barasingha kills range 25 to 50 percent in different populations (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Qureshi et al. 1995). Deaths in barasingha due to disease are not recorded. Schaller (1967) did mention of abortion of fetus due to brucellosis. The barasingha populations occur in areas where rinderpest, foot and mouth disease, brucellosis, hemorrhagic septicemia and anthrax were reported in wild as well as livestock populations. The ectoparasites like house flies, ticks and lice and endoparasites like flukes, lungworms *Eucheria coli* and '*Mange'* are reported to occur in barasingha population but no death due to any of these is observed (Schaller 1967, Schaff 1978, Arora 1990, Qureshi et al. 1995).

Barasingha utilize variety of habitat types including open forest where grasses are present, maximum abundance was observed in marshy and sandy grasslands (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Gopal 1995, Qureshi et al. 1995). Barasingha were seen moving through forested habitats when they shift to different habitats as per their seasonal needs (Martin 1977, Schaff 1978, Qureshi et al. 1995). The composite home

range of herds range from 10 to 30 km2, annually (Qureshi et al. 1995). Barasingha on an average move 2-3 km (straight line) daily and known to move distances of 5-7 km during seasonal shifts of habitat (Martin 1977, Schaff 1978, Singh 1985, Sankaran 1989, Qureshi et al. 1995). Barasingha is primarily a grazer and largely feed on grasses and aquatic plants. Some of the most utilized species were *Saccharum* spp., *Imperata cylindrica*, *Narenga porphyrocoma*, *Phragmites karka*, *Oryza rufipogon*, *Hygroryza* spp., and *Hydrilla* spp. (Schaller 1967, Martin 1977, Schaff 1978 and Singh 1984, Moe 1994, Qureshi et al. 1995). The drinking of water varies with season, twice in winter and monsoon to thrice or more in summer. The feeding happens through out the day which peaks during 5 to 11 hrs and 15 to 20 hrs. The timing varies between seasons, during summer morning feeding ends early and evening bout start late (Martin 1977, Schaff 1978, Singh 1984, Qureshi et al.1995). During summer animal do rest under trees shades and it is quite common to see them sitting in open. Habitat use is largely influenced by food quality. Grassland burning significantly affects the movement and choice of food species. Most of the grass species within 15 days of burning produce succulent and palatable shoots, thus barasingha is less choosy during this time (mid winter burning period) (Martin 1977, Schaff 1978, Qureshi et al. 1995). The specific habitat requirement for rutting is shallow wetland surrounded by tall grasses and for fawning the tall upland grasslands (Martin 1977, Qureshi et al. 1995). Barasingha avoids using areas grazed by livestock. The habitat use is largely influenced by food quality.

1.3.3 Behaviour

Barasingha is polygynous, males and females have linear hierarchy, and during rut males tend to defend females in estrous (Schaller 1967, Martin 1977, Schaff 1978, Singh 1985, Qureshi et al. 1995). Stags settle dominance by sparring and body size displays amongst them while hinds exhibit dominance by pushing other hinds from preferred resting or feeding sites, by butting, kicking by foreleg and thumping ground (Singh 1984, Qureshi et al. 1995). Mating in *C. duvauceli* occurs during winter, most of the stags are in hard antler by September, and they start bugling by then. Bugling peaks

during mid October to November with earliest call in mid August to as late as mid April and as season progresses the evening bugling peak shifts to morning (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Qureshi et al. 1995). The rutting starts for *duvauceli* in August – September, while antler shedding begins by mid January (Schaller 1967, Prater 1971, Singh 1984, Qureshi et al. 1995).

Barasingha are highly fidel in use of rutting grounds, so much so that in Kanha and Dudhwa they visit rutting grounds outside their feeding areas which have now been converted into agricultural fields (Schaller 1967, Martin 1977, Schaff 1978, Qureshi et al. 1995). Adult stags generally create wallows by digging soil by antler and fore feet, these wallows are churned regularly, stag rolls and urinate in it to leave scent secreted by inter digital glands (Schaller 1967, Martin 1977, Singh 1984, Qureshi et al. 1995). The stags rub their body and neck against tall grasses for marking (Singh 1984). The stag sniff the genital of hinds, or urine and do flehmen to assess estrous condition in hinds (Schaller 1967, Martin 1977, Singh 1984, Qureshi et al. 1995). The female behaviour is very subtle and seems to keep track of male dominance as they allow largely dominant or other high ranking stags to copulate. Barasingha stag approach females with submissive posture, outstretched neck with antlers held parallel to ground and ears held laterally. Receptive hind generally makes no attempt to escape from dominant stag and at times seen following and encircling stag (Singh 1984, Qureshi et al. 1995).

The fawning peak occurs in July to August in Barasingha (Schaller 1967, Singh 1984, Qureshi et al. 1995). Hinds segregate from herd to give birth in selected tall grass areas and fawn remain in this surrounding for approximately 7 to 15 days, fawn is introduced to herd as soon as it is able to follow mother (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Qureshi et al. 1995). Hinds visit the hiding sites and make soft moaning calls for fawns to suckle (Singh 1984, Qureshi et al. 1995).

Barasingha have keen sense of hearing and smell. Barasingha behaviour to detect and communicate danger are, the alert posture with and without tail being raised, thumping ground by foreleg, scanning for danger,

alarm call, and forming tightly bunched group (Schaller 1967, Martin 1975, Schaff 1978, Singh 1984, Qureshi et al. 1995).

1.3.4 Conservation

Barasingha populations are presently confined to a few protected areas, with exception of Bijnor and Pilibhit Divisions (U.P.), Banganga and Jhilmil (UK). Some populations like that of Dudhwa and Kaziranga seasonally move out of protected areas. The habitat of barasingha is more threatened being flood plain grassland, change in river dynamics due to human developmental activities, increase in siltation and reduced flow of water during critical periods of summer. The management earlier treated these grasslands as useless (termed blanks) and extensively planted and destroyed large areas of habitat.

Though Barasingha meat is not considered a delicacy yet they are occasionally poached for antler and meat. The populations outside protected areas as well as seasonally migrating population need to be protected. Barasingha population recovered in most of its range in North and Central India once grazing was controlled (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Qureshi et al. 1995).

Table 1.1 Status of Barasingha in 1965 (Schaller 1967) and present (based on Qureshi et al. 1995).*

Location	1965	Present (Based on Qureshi et al. 1995)
Nepal		
Sukla Phanta Sanctuary and Kanchanpur	1000	1600
Bardia Division	200	50-100
Banke Division	A few	-
Chitwan Division	A few	Extinct
India		
Jaulasal Sanctuary	Fewer than 100	Extinct
Lalkua and Maldhan Sanctuary	Very few, if any	Extinct
Along Ganges River, West of Bijnor	Probably some	-
Along Ganges River, West of handpur	100(+)(-)	-
Between Hardwar and Luksor	1 doe shot in 1963	
Dudhwa Tiger Reserve	~1200	1200 - 1400
Sonaripur Sanctuary	Fewer than 50	-
South Kheri Forest Division	Fewer than 200	-
Bahdi Tal, 6 miles west of Bellerain	A few	-
Ghola and surrounding tracts	800-900	-
Kishanpur and Katerniaghat Sanctuary	-	-
Mirchia, bordering Nepal	A few	Extinct
West Bengal		
Jaldapara Sanctuary and surrounding forest	A few	Extinct
Assam		
Manas Sanctuary	Perhaps a few	Status Indeterminate
Darang Division along Bhutan border	A few	Extinct
Kaziranga Sanctuary	200-250	450 - 500
Madhya Pradesh		
Kanha National Park	~50	300 - 350
Motinala and Karanjia ranges, Mandla District	A few seen	Extinct
Balaghat District between Baihar and Lamba	Several seen in	Extinct
Near Amarkantak, Bilaspur District	A few	Extinct
Near Kota, Bilaspur District	1 stag shot in 1960	Extinct
Madhya Pradesh-Orissa border Raipur District	100(+)(-)	Extinct
West Bastar Division near Tekemeta	4 seen in 1963	Extinct
West Bastar Division near	Rare	Extinct

*Additions: Hastinapur Wildlife Sanctuary, Western Uttar Pradesh-<100

Banganga wetland, Uttarakhand-80

Jhilmil Jheel Conservation Reserve-150

1.4 OBJECTIVES

The study objectives were as follows:

1. To study the habitat use pattern by swamp deer in the Jhilmil Jheel area during various seasons,
2. To study the food habits and forage availability,
3. To assess the habitat condition for swamp deer around Jhilmil Jheel and assess the population structure of swamp deer.
4. To identify threats and suggest conservation measures.

In order to achieve the above objectives following specific questions were addressed during the course of study:

(i) what is the habitat use pattern of swamp deer around Jhilmil Jheel during various seasons,
(ii) what are the cover requirements during fawning season,
(iii) what are the major food plants consumed by swamp deer during various seasons ,
(iv) what is the relative abundance or availability of major food plants in the area,
(v) what is the floristic structure of wetland vegetation in the study area,
(vi) whether there is any variation in group composition, total number of individuals, fawn to adult ratio, male to female ratio during various seasons,
(vii) what is the status of swamp deer habitat along the flood plains of Ganges adjacent to the study area and
(viii) what are the immediate threats to the habitat and species and what are the possible conservation measures.

1.5 Organization of the thesis

The thesis is organized into nine chapters. After a brief introduction in chapter 1, literature is reviewed in chapter 2. The study area has been

described in chapter 3, followed by habitat use pattern in chapter 4 and food habits in chapter 5. Seasonal activity pattern are discussed in chapter 6 and population structure in chapter 7. A detailed description of the habitat and assessment of the conservation threats to swamp deer and study area are given in chapter 8. Specific methods and statistical analysis regarding the results is presented in each chapter separately. At the end in chapter 9, a general discussion regarding conservation strategy and management recommendations in presented.

Chapter 2

Review of Literature

An extensive body of literature exists on cervid ecology. In this chapter, an attempt has been made to review the literature related mainly to habitat ecology of tropical gregarious cervids. This review largely pertains to, cervid habitat use pattern, food habits, group structure, activity pattern and their home range sizes.

2.1 Ecology

One of the well studied tropical cervids in the tropical grasslands of Indian sub-region is Hog deer (*Axis porcinus*). Dhungel et al (1991) studied the ecology of this species in Royal Chitwan National Park, Nepal during 1981-83 to obtain information on the morphological features, sex and age ratios, group size and composition, reproduction, mortality, movement, activity patterns, home ranges, habitat use, food habits, food availability, and behavior. They captured and measured ninety-five hog deer, radio collared 21 of them and monitored for 6,250 hours. Maximum weights (mean for males = 42.7 kg; mean for females = 32.2 kg) and lengths (mean for males = 1,278 mm; mean for females = 1,206 mm) were attained at 2-3 years of age. The hog deer is listed as endangered throughout its range in South Asia. In Chitwan National Park, it is one of the principal prey species of the endangered Bengal tiger (*Panthera tigris*). Sex ratio of captured and observed (n = 570) deer was 56 males: 100 females. Groups of up to 20 deer were observed during February through April, after the first fires in the grasslands, but the basic social group consisted of an adult female and her juvenile offspring. The peak fawning season was March through April, but females gave birth from the end of January through April. One female had a documented 213-day gestation period. Both males and females attained sexual maturity at about 15 months. Litter size was normally 1, and 13 fawns/100 adults were observed in the field. During all seasons, the deer fed in the mornings and evenings and bedded and ruminated during the hot part of the day. They were found active during 41% of the day and 26-29% of the night. Home ranges overlapped extensively, and mean home ranges were

estimated at 60 ha for females and 80 ha for males. Home range shape was dictated by food and water. Small home ranges indicated that hog deer were sedentary, preferring grasslands where food, cover, and water were available. Habitat use, based on transmitter locations and direct observations, showed that hog deer used grasslands almost exclusively and preferred grasslands to sal (*Shorea robusta*) and riverine forests. Foraging and feeding behavior, recorded inside a 4-ha enclosure, indicated that grasses, ferns, semal (*Bombax ceiba*) flowers, and vellor (*Trewia nudiflora*) fruits were important food items. *Saccharum* spp.*, Imperata cylindrica,* and *Cynodon dactylon* composed 70% of the grass species available as food and cover. Tall grasses seem to be invading short grasslands, reducing available food for hog deer. They suggested conducting experiments on increasing interspersion of short grasses for food and tall grasses for cover. They also recommended research on succession that could facilitate development of future management strategies.

Tak et al (1981) studied hog deer at Dhikala, Corbett National Park, from January, 1977 to June, 1979. They found that its herd size varied from 2-35 individuals. The average ratios of male to 100 females varied from 56.7 to 85.9, yearlings to females (100) from 4.6 to 11.2 and of fawns to females (100) from 28.6 to 55.5. It preferred grasslands along the river beds and open grassy plains. They also showed bimodal activity pattern. It was found to be primarily a grazer and preferred sprouting grasses.

Aung et al (2001) studied thamin at Chatthin Wildlife Sanctuary, Central Myanmar from 1995 to 1999. They radio tracked 11 adult male and 8 adult females. Based on 747 sightings, a 0.63:1.0 adult male: female ratio and 0.51:1.0 fawn: adult female ratio were observed. Mean group size was variable (1.0-5.9 deer) and showed seasonal differences, with few groups observed in August-September and groups of ≤70 individuals observed in March-April. Based on the fixed-kernel method, annual home range was 9.04 km^2/± 5.67 SD and 7.25 km^2/± 3.45 SD for males and females, respectively. Thamin increased their seasonal home range during the hot-dry season,

possibly in response to decreased forage and water availability and increased mating activity. The observed synchrony of estrous onset (March-April) and fawning (October-November) in female thamin is unusual for a tropical cervid species, but reproductive seasonality appears timed to balance fawn survival with doe nutrition in a monsoon environment.

Martin (1977) studied status and ecology of the barasingha (*Rucervus duvaucelii branderi*) in Kanha National Park (Madhya Pradesh) considering drastic decrease of its population since the beginning of 20th century. He found dispersion to be largely restricted to grassy meadows throughout the year. The population was found congregating in that part of its annual home range which had maximum water bodies. Barasingha showed synchronized diurnal activity patterns during cool and dry season. Feeding was done mostly around sunrise and sunset and travelling during the rest of the day. The utilization pattern was governed by availability of open rivulets and unburnt patches of grassland. Their food included green perennial grasses like *Saccharum spontaneum* and *Themada triandra*. Mean monthly group sizes varied between 3.7 and 13.1 animals/group. Largest aggregations were observed at the end of the rutting seasons. Females with fawn at the foot and yearlings tended to remain in open areas more than other classes.

Gopal (1995) studied biology and ecology of hard ground barasingha in Kanha National Park. He made detailed investigations of various aspects viz., morphology, anatomy, physiology, karyotype analysis, intra and interspecific relationship, ethology and population dynamics. His study confirmed the fact that hard ground barasingha is a large sized specialized deer with well developed, shallow, preorbital glands. It exhibits all the structural, cursorial specializations diagnostic of the ungulates, artiodactyls and ruminants in general, and Peccorans in particular. Like other ungulates, the hard ground barasingha has also evolved ‘antipredator strategies’ to save itself from predation. Predation and fawn mortality due to lack of adequate fawning cover, have contributed to decline in the recent past, though the spotted deer serves as a good “buffer” species, often saving the barasingha from becoming

the targets of predators. Its interactions with other herbivores and birds indicate interspecific cooperations.

Kotwal et al (1992) studied management of hard ground barasingha in Kanha National Park. They discussed how restorative efforts of habitat amelioration and water hole development revived the population of 66 in 1970-77 to 540 in 1989.

Singh (1984) studied bio-ecology of swamp deer in Sathiana block of Dudhwa National Park from 1978-1981. They found the animal gregarious, less nocturnal with diurnal activity pattern. They prefer grassy forests or open patches and feed throughout on fresh grassy shoots. Rutting appeared in winter and hind: stag ratio was 2.5:1. Herd size was 29-39 post-breeding season and 4-19 in the rest of year. He found that several developmental activities have led to destruction of its habitat.

Hussain et al (2006) reviewed the status and ecology of Sangai (*Cervus eldi eldi*) in Keibul Lamjao National Park, Manipur. They found that the mean sex ratio was 79.38$\pm$2.5 males per 100 females. The doe to fawn ratio was 100: 37.1$\pm$3.8. The Sangai use *phumdis* (floating mass of entangled vegetation, formed by the accumulation of organic debris and biomass with soil particles), hillocks and elevated strips of land along the lake. However, the phumdis forms the main habitat, which provides food, shelter and breeding sites. The Sangai is a seasonal breeder with highest peak in March. Like may other deer species, Sangai is a seasonally monoestrous. The mature female delivers a fawn during October-November, after a gestation period of 245-273 days (Shanmugou, 1992). The common food species were *Zizania latifolia*, *Saccharum* spp*., Erianthus* and *Capillipedium* spp. Sangai exhibit bimodal activity pattern with distinct morning and evening peaks. The major problem which Sangai are facing in the park is in the form of alteration in the structure and composition of the *phumdis*. This is largely due to construction of Ethai barrage which has changed the natural water regime of the park (Panwar, 1979).

Sankar (1994) studied ecology of chital in Sariska Tiger Reserve. He found highest congregation of chital in area with availability of fallen leaves and fruits of *Zizyphus mauritiana* during winter and green grass sprout during summer. Chital fed exclusively on grass during monsoon. The seasonal group size varied from 2 to 88 individuals with a mean (±SD) group size of 7.8±8.3 (n=694). The absence of open grass patches restricted chital from forming larger groups. The average male: female ratio was 0.47:1 and the female: fawn ratio was 1:0.22. Chital largely used scrubland in summer, *Anogeissus* forest in monsoon and post-monsoon and *Butea-Zizyphus* mixed forest in winter.

2.2 Habitat use

Mc Shea et al (1999) mapped the current distribution of thamin (*Cervus eldi thamin*) using ground surveys and tied this information to habitat types derived from satellite images in order to detect patterns that might indicate the landscape features. They conducted a survey of 24 out of 28 Myanmar townships that were reported to contain thamin in 1992, and evidence of thamin were found in 23 of these townships, predominately in mixed deciduous forests where Dipterocarp trees were present. There was no significant correlation between the number of thamin detected and forest remaining in the township, or the size of the human or livestock population. A landcover classification of Landsat Thematic Mapper images indicated 58% of the study area contained deciduous forest, of which 12% was Dipterocarp forest. Forested tracts containing thamin were digitized and landscape analyses were conducted on a resampled habitat map that emphasized dry deciduous (Dipterocarp) forest. Of six landscape variables measured only core area size was a significant predictor for the presence of thamin. None of the unsurveyed forests possessed a core area large enough to support thamin. The pattern of thamin decline matches predictions that peripheral, rather than central; populations are more likely to persist in declining species.

Mc Shea et al (2001) monitored use of plants and habitat in a population of thamin in Chatthin Wildlife Sanctuary in central Myanmar from 1996 through 1999. Habitat use within the deciduous Dipterocarp forest was monitored by radiotracking 19 individuals during daylight hours and conducting biannual fecal pellet surveys along 87 km of marked transects. Habitat availability was determined by classifying a LANDSAT image of the region, collecting vegetation parameters from 201 plots located within the sanctuary, and pacing habitat types along marked transects. Thamin consumed primarily forbs, grasses, and agricultural crops but also fruits of 8 common tree species. They used Dipterocarp forests but showed some seasonal shifts and distinct individual differences in habitat use. Except during of the mating season (January-April), females were found more often in degraded forests and closer to crops than males. Sex differences in habitat selection were due to either female selection of habitats with lower predation risk or increased nutritional needs associated with lactation.

Chakrabarty (1991) studied the habitat use by radio instrumented chital in Sariska Tiger Reserve. He found that the distance moved by the animal during different time of day varied both in winter and summer. It was more active during day in winter. Its summer home range was smaller than its winter home range. The home range size was inversely related to the amount of browse. Chital showed a preference for flat terrain in both seasons. *Zizyphus* mixed vegetation and *Acacia* mixed scrub were preferred by chital during winter and summer respectively. It showed a preference for the tree density of (50-100 tree/ha) class, grass cover of (50-75%) class and herb cover of (25-50%) class in winter. In summer the preference was for tree density of (50-150 tree/ha) class, grass cover of (25-50%) class and herb cover of (50-75%) class.

Raman et al (1996) studied the population structure, density and seasonal habitat use, and feeding habits of chital in 2.7 km^2 Guindy National Park (Tamil Nadu) using line transects during 1991-92, and compared these with observations made during 1975-82 in the park. The chital population

(density of 212.3/km^2 during 1991-92) has been stable or even increased between 1975 and 1992. Artificial feeding may be responsible for low infant and adult mortality and thus for maintaining very high chital density.

Bhat (1993) studied habitat use by chital in Dhaulkhand, Rajaji National Park and found that density of chital is same in hills and plains in winter and summer. In hills, it used forests more than woodland. Seasonal shift in habitat use was marked in plains. In winter, sal forests were used less and mix forest plantation more. However, it preferred forests with higher canopy cover and sparse shrub and ground cover during summer. Moderate hill slopes (11-30°), valleys and ridge lines were more utilized. Food, water, cover, terrain, weather (particularly wind), association with langurs and monkeys and human influence in the form of fire, lopping and grass cutting were identified as the factors governing habitat use pattern.

2.3 Activity pattern

Studies on behavioral patterns in ungulates have been instrumental in understanding of social organization, foraging ecology, and ecology, and evolutionary relationships (Geist 1971; Jarman 1974; Schaller 1977). Such work also is of value in assessing effects of disturbance and other aspects of interest to wildlife managers (Geist and Walthers, 1974; Stockwell et al, 1991).
A number of studies have reported activity patterns of different animals. Activity pattern of Reeve's muntjac (Yahner et al 1980), mule deer (Eberhardt et al 1984), hog deer (Dhungel et al 1991), sambar (Bhatnagar 1991), sambar (Semiadi et al 1994), mouse deer (Matsubayashi et al 2001), sambar (Yamada et al 2002), red deer (Kamler et al 2004), swamp deer (Qureshi et al 1995 and Khan et al 2004), hog deer and Indian muntjac (Odeen et al 2006) have been studied in their natural condition.

2.4 Population structure

Knowledge of animal population, their structure, and the trend are of paramount importance for wildlife management. This is especially true of an

animal contributing a larger proportion of biomass to the population of an area even in small numbers. Herbivores normally tend to live in groups which may vary widely within species (Eisenberg, 1966; Crook et al., 1976; McBride 1976; Rodman, 1981; Johnson, 1983). The pattern in group size is considered to be influenced by environmental conditions prevalent in the area (Leuthold and Leuthold, 1975; Southwell, 1984). Barrette (1991) discussed the significance of studies on group composition, size and structure. Further, studies on group composition could yield very useful information on population characteristics and trend (McCullough, 1993 and 1994).

Chapter 3

Study Area

CHAPTER 3
STUDY AREA

3.1 General

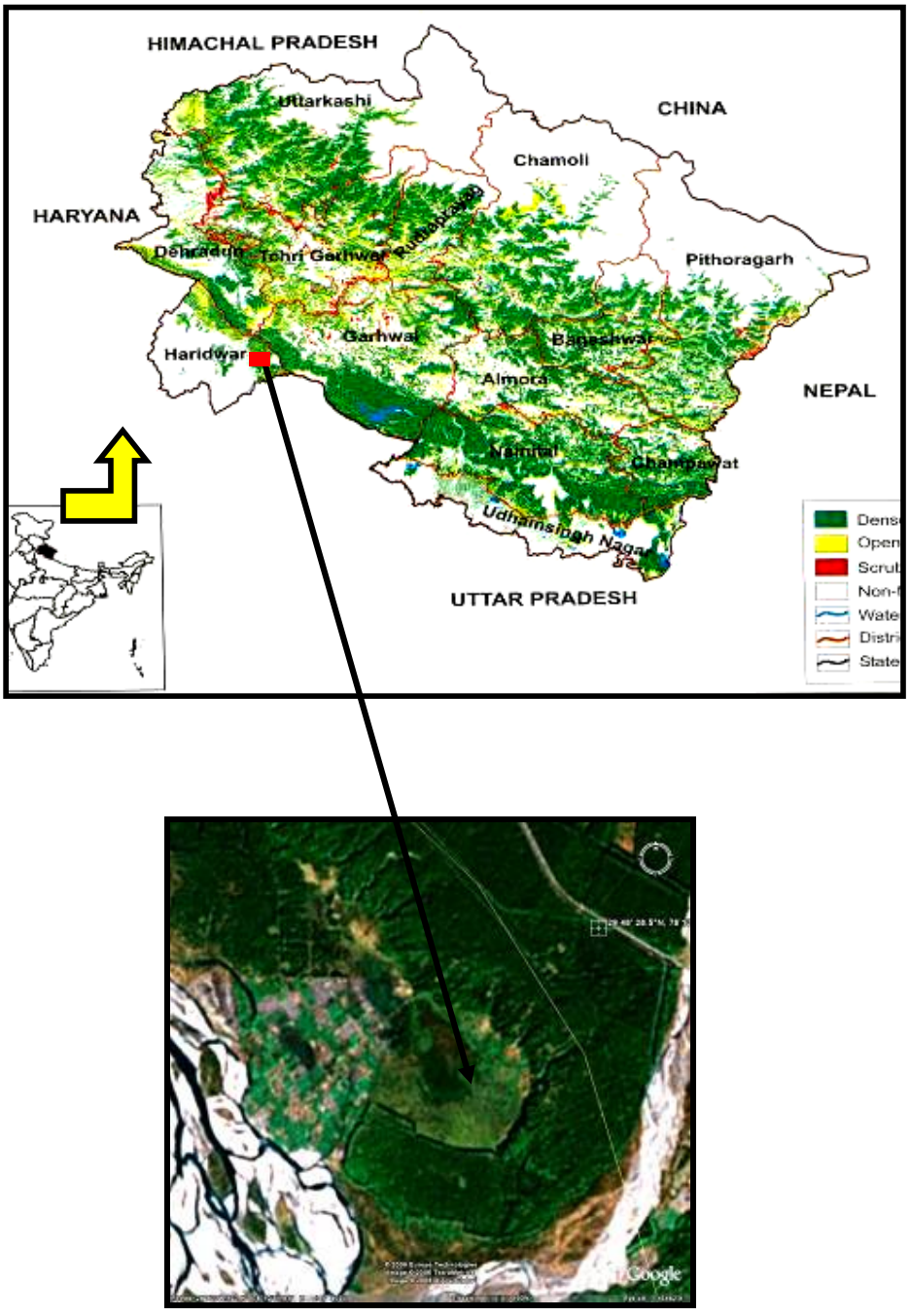
The study was conducted in and around Jhilmil Jheel Conservation Reserve (JJCR). This reserve is located in Haridwar Forest Division of Uttarakhand state. It is surrounded by Bijnor Forest Division (Uttar Pradesh) on one side and Dehradun Forest Division on the other (Fig.3.1).

It is situated at a distance of 20 kms from Haridwar town. One all weather road from National highway goes to the Rasiabadh complex, consisting of one renovated forest rest house with number of staff quarters and an interpretation centre. This road terminates at Tantwala village which is situated on the left bank of river Ganga.

3.1.1 Intensive study area

Jhilmil Jheel is a saucer shaped wetland situated on the left bank of River Ganges between N 29^0 32' to 29^0 50' and E 78^0 to 78^0 15' covering an area of 3783.50 ha of Reserve Forest. The altitude of the area varies from 200 to 250 meters above mean sea level. It is located on the Haridwar – Najibabad Highway and besides the natural course of the Ganges to the south of it in Chidiyapur Forest Range of Haridwar Forest Division, Uttarakhand. It is connected to River Ganga and is surrounded by Reserve Forest of Chidiyapur Range (Fig. 3.2).

The habitat is located at the junction of the Bhabhar and Terai formations representing a unique and species rich ecosystem which encompasses spectacular landscapes, tall grasslands, and tropical moist deciduous forests.



Intensive study area

Figure 3.1 Location map of Jhilmil Jheel Conservation Reserve

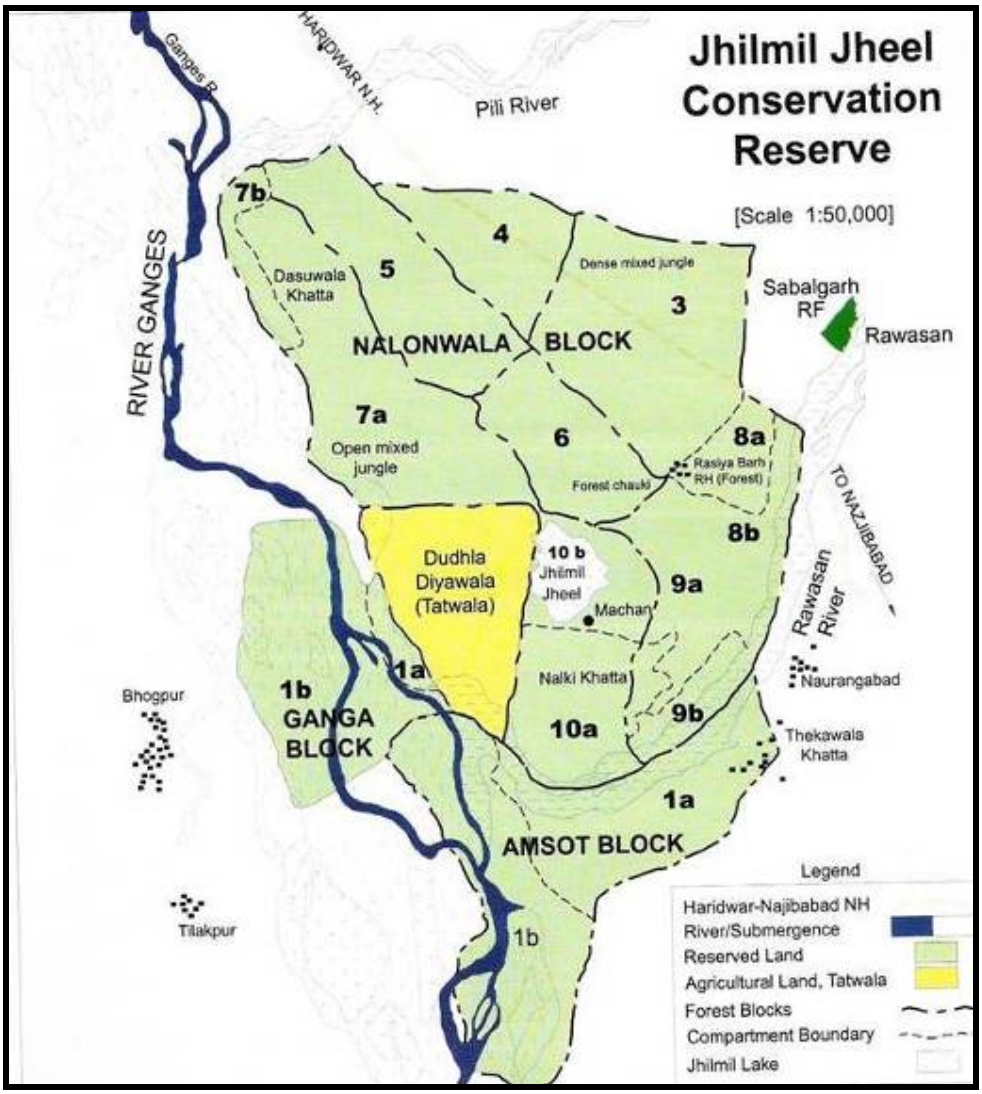


Figure 3.2 Map of study area

3.2 Physical characteristics

3.2.1 Topography

These swamps (‘*tals*’) and streams significantly contribute in making the diverse habitats. In addition to these perennial swamps, there are many low-lying areas or depressions those retain rain water for some time after monsoon season and provide drinking water to wild animals. The area comes under the Bhabhar-Terai zone with undulating terrain and mix woodland habitat. Some areas have plantation of Eucalyptus monoculture while others have open grassland with sparse woody trees of riverine habitat. The broad riparian zone of River Ganga has sandy loam; while river Rawasan which joins to River Ganga at southern boundary of Jhilmil Jheel conservation reserve has accumulation of boulders in its entire stress.

A number of small rivulets emerge from the woodland and discharge into Jhilmil Jheel, which finally drain into the Ganges. Jhilmil Jheel receives water from the Shivaliks formations of Chidiyapur and adjacent ranges as underground streams, locally called ‘Choyas’. This area also received water from the overflow of river Ganga. A total of 32 ‘choyas’ have been noticed around the Jheel area. Most of them provide water throughout the year, while some dry up for about 6-7 months.

3.2.2 Geology and soil

Geologically, the tract belongs to the Gangetic plains. The northern belt of the tract (about 3-4 miles wide) belongs to the Bhabhar formation consisting of alluvial deposits underlain with bouldery detritus brought down by various streams and becomes highly porous and characteristically dry except in the rainy season. Further, to the south the tract grades into terai region where the hill detritus gradually disappears from the surface, the soil gets deeper and occassionaly sub-terranean water oozes out and causes water logging.

The texture of the soil varies from fine sand to clayey loam. During monsoon, the rivers inundate large areas of lowland grasslands for 3-4 months. Flooding rivers and meandering channels have considerable influence on the spatial pattern of the landscape, particularly grasslands and riverine forests. Erosion and accretion elsewhere are inherent dynamic process of the *Terai* ecosystem. Flood waters carry considerable amounts of silt, which is deposited in floodplain grasslands and forests. Shifting of river channels over time has left behind many old channels where numerous seasonal and perennial swamps ('*tals*') or wetlands occur. The central part of the reserve represents one such oxbow lake formed along the eastern bank of Ganges. Surrounding areas get submerged during the monsoon.

3.2.3 Climate

The area experiences sub-tropical climate, coldest month being January when temperature drops as low as 2° C. Winter rains and subsequent heavy fog are also prevalent in the area. Summer is very hot and humid like any other Terai area when temperature soars up to 44° C, often accompanied by hot dust storms.

The area experiences heavy rains during June-September (monsoon). Mean average rainfall in the area is 1300 mm per annum recorded between 1997 to 2007. Most of the rain falls between July to September. This particular area experiences irregular rainfall and less as compared to neighbouring areas.

Relative humidity of Jhilmil Jheel area ranges between 45-80%. Highest relative humidity is observed during rainy season.

3.3 Biological attributes

3.3.1 Vegetation

The Upper Gangetic Plain forms a distinct bio-geographic zone (7) (Rodgers & Panwar 1988). This area, popularly known as *Terai*, is

characterized by fine alluvium with high water table dominated by a mosaic of hygrophilous grassland and miscellaneous forests, generally categorized under Tropical Moist Deciduous Forests (Champion & Seth 1968).

3.3.2 Flora

The vegetation of the study area can be categorized into following physiognomic types:

1. Moist (mixed) deciduous forest
2. Riverine forest
3. Secondary scrub
4. Grassland

1. Moist (mixed) deciduous forest: This category is spread over 5.18% of the area. The characteristic species in this forest are *Alangium salvifolium, Albizia lebbeck, A. procera, Anogeissus latifolia, Bauhinia malabarica, Butea monosperma, Crataeva religiosa, Diospyros montana, Ehretia laevis, Ficus benghalensis, Grewia tiliifolia, Haldina cordiflolia, Holoptelia integrifolia, Mitragyna parvifolia* and *Terminalia belerica*. The middle storey consists of *Aegle marmelos, Cassia fistula, Cordia dichotoma, Emblica officinalis, Ficus racemosa, Melia azeadarach, Mallotus philippensis,* and *Pongamia pinnata*.

The common shrubs of these forests are *Adhatoda zeylanica, Calotropis procera, Carissa opaca, Cassia occidentalis, Catunaregam spinosa, Clerodendrum viscosum, Helicteres isora, Limonia acidissima,* and *Murraya koenigii.* The common grasses found in this forest are *Brachiaria ramosa, Chloris dolichostachya, Dactyloctenium aegyptium, Desmostachya bipinnata, Hemarthria compressa, Ischaemum indicum,* and *Oplismenus compositus*. The herbs found in this vegetation type are *Aerva lanata*, *Curcuma aromatica*, *Dicliptera roxburghiana*, *Evolvulus nummularius, Hemigraphis rupestris*, *Perilepta auriculata*, *Perilla frutescens*, *Rungia pectinata*, *Sida rhombifolia*, *Tephrosia purpurea,* and *Vernonia cinerea*. Among pteridophytes *Adiantum edgeworthii* is most frequent. The common climbers are *Abrus precatorius, Cissampelos pareira, Ichnocarpous frutescens, Ipomoea nil* and *Vallaris solancaea*.

2. Riverine forests: This type of forest occupies mainly in the nallahs and along the river beds of Rawason and River Ganga. The common species of these forests are: *Acacia catechu*, *Bombax ceiba*, *Ficus palmata, Gmelina arborea, Morus alba, Oroxylum indicum, Syzgium cumini* and *Trewia nudiflora.* The under storey species consists of grasses *Eragrostis gangetica, Paspalum scrobiculatum, Saccharum bengalense, S. spontaneum, Sporobolus diander* and *Themada* sp. and sedges *Cyperus iria, C. niveus, C. nutans* and *C. rotundus.* Some common herbs are *Bacopa procumbens*, *Boerhaavia diffusa*, *Centella asiatica, Chenopodium ambrosoides, Cleome gynandra, Desmodium velutinum, Erigeron* sp.*, Linum usitatissimum, Ipomoea pes-tigridis, Launaea procumbens, Leonotis nepetifolia, Leucas cephalotus, Mazus pumilus, Nelsonia canescens, Peperomia pellucida, Pupalia lappacea, Scoparia dulcis, Solanum xanthocarpum,* and *Youngia japonica*. The common climbers are *Tinospora cordiflolia* and *Zehneria scabra*. Other than this in some parts they are occupied by plantation of *Eucalyptus* and *Dalbergia sissoo*.

3. Secondary scrub: These are formed at the edge of swamp, where soil is poor, thin, and wet for bigger trees to grow. The main tree species found in those areas are *Acacia nilotica*, *Broussonetia papyrifera, Psidium guajava,* and *Zizyphus mauritiana*. The common shrubs are *Lantana camara* and *Rubus ellipticus*. The undergrowth consists of grasses like *Apluda mutica*, *Chrysopogon fulvus*, *Cymbopogon* sp., and *Cynoglossum* sp., herbs like *Cannabis sativa*, *Desmodium gangeticum*, *Medicago lupulina*, *Solanum viarum*, *Uraria rufescens*, *Urena lobata,* and *Viola betonicifolia*, climbers like *Coccinia grandis* and pteridophytes like *Goniopteris* sp. and *Thelypteris dentata*.

4. Grassland: Grassland in Jhilmil Jheel Conservation Reserve is spread over an area of more than one square kilometers and also present in small patches in other parts for the reserve. Frequent grasses include *Coix lacryma-jobi*, *Cyrtococcum accrescens, Eragrostis stenophylla, Phragmites karka, Cynodon dactylon, Imperata cylindrica*, *Pennisetum glaucum, Vetiveria zizanioides*, *Echinochloa colonum, Eleusine indica, Paspalum conjugatum*

and *Polypogon fugax,* sedges comprise of *Carex myosurus, Cyperus bervifolius*, *C. compressus, C. cyperoides, C. kyllingia, Elaeocharis tetraquetra, Eriocaulon* sp.*, Fimbristylis dichotoma, F. miliacea, Juncus bufonius* and *Scirpus lateriflorus* and climbers like *Momordica dioica, Vicia sativa* and *Vigna vexillata* are the main climbers in the area.

Inside the grassland there are small pools of water which retain water and form a swampy habitat which is one of the prime habitats for the swamp deer and in such habitat hydrophytes plays an important role. Hydrophytes reported in Jhilmil Jheel area are *Ceratophyllum demersum*, *Hydrilla verticillata*, *Hygrophila polysperma*, *Ludwigia adscendens*, *Monochoria* sp., *Najas graminea*, *Nymphoides cristata*, *Potamogeton crispus*, *P. nodosus*, *Sagittaria trifolia*, *Typha angustifolia*, *T. elephantina,* and *Utricularia* sp. The pteridophyte reported is *Equisetum ramosissimum.*

The grasslands are interspersed with trees such as *Celtis tetrandra, Salix tetrasperma,* and herbs e.g. *Xanthium indicum, Alysicarpus vaginalis*, *Blainvillea acmella*, *Caesulia axillaris*, *Eclipta prostrata*, *Hemigraphis latebrosa*, *Mosla dianthera*, *Oenanthe javanica,* and *Oxalis corniculata.*

Plantations

A number of exotics and native species have been tried in the plantation from time to time. The following are particularly worth mentioning:

1. Teak (*Tectona grandis*)
2. Eucalyptus (hybrid)
3. Sheesham (*Dalbergia sissoo*)
4. Khair (*Acacia catechu*)

3.3.3 Fauna

Jhilmil Jheel Conservation Reserve represents a typical *Terai* habitat island. This area though very small, supports a rich array of faunal diversity including common leopard (*Panthera pardus*), sloth bear (*Melursus ursinus*),

and tiger (*Panthera tigris*). Lesser carnivores are represented by the Jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Smooth-Coated Otter (*Lutrogale perspicillata*), Himalayan Yellow throated Marten (*Martes flavigula*), Small Indian Civet (*Viverricula indica*) and Grey Mongoose (*Herpestes edwardsii*). Other herbivores, i.e., Sambar (*Cervus unicolor*), swamp deer (the flagship species), barking deer (*Muntiacus muntjac*), hog deer (*Axis porcinus*), spotted deer (*Axis axis*), Nilgai (*Boselaphus tragocamelus*), wild pig (*Sus scrofa*), and frequently Asian elephant (*Elephas maximus*) can also be seen in this area. Both common langur (*Semnopithecus entellus*) and Rhesus macaque (*Macaca mulatta*) are found in the conservation reserve.

Reptiles are represented by Indian Python (*Python molurus*), Common krait (*Bungarus caeruleus*), Indian cobra (*Naja naja*), checkered keelback (*Xenochrophis piscator*), and the Monitor lizard (*Varanus bengalensis*). Marsh Crocodile is found in the riverine zone while six species of tortoises and two species of turtles are found in the seasonally waterlogged areas (*pers. obs.*).

A total number of 260 species of birds were recorded in the conservation reserve area including both resident and migratory birds (*pers. obs.*).

Table 3.1 Area under different land use/ land covers types in the Conservation Reserve

S. No.	LULC	Area in km^2	% of CR Area
1	Mixed Moist Deciduous Forest	1.96	5.18
2	Secondary Scrub	0.25	0.66
3	Tall Wet grassland	0.49	1.28
4	Short Dry grassland	0.75	1.98
5	Eucalyptus Plantation	22.85	60.39
6	*Dalbergia sissoo* Plantation	2.63	6.94
7	*Tectona grandis* Plantation	0.87	2.30
8	*Acacia catechu* Plantation	6.38	16.87
9	Mixed plantation	1.52	4.01
10	Water bodies	0.04	0.11
11	Riverine forest	0.10	0.27
	Total area	**37.84**	**100**

3.4 Human use

Tantwala village, earlier known as Dudhiya Dayalwala, is the only habitation adjacent to Jhilmil Jheel consisting of 146 households. The local inhabitants are from different communities viz., Punjabis, Gujjars, Banjaras, Sainis, Himachalis, and Garhwalis, migrated from different parts in early 1950's. The villagers of Tantwala are reported to be largely vegetarians and do not consume alcohol as they are followers of a particular spiritual sect. These villagers strongly support conservation of Swamp deer in Jhilmil Jheel.

Before the declaration of the conservation reserve people were freely grazing their livestock in the grasslands of Jhilmil Jheel area. Livestock from outside of conservation reserve also come for grazing in this area. Gujjars were rehabilitated outside of reserve area along the River Rawasan. They graze their livestock in the Jhilmil Jheel area. It is estimated that more than 1300 cattle graze in the conservation Reserve on daily basis.

3.5 History of management

The early history of the forests of Mohanwali and Amsot Forests Blocks were dealt in the working plans of Lansdowne Forest Division, of which these forests formed a part till 1957. Briefly, these forests came under British rule from 1820. The Forest Department took over the management in 1879 as these forests were declared as Reserve Forests vide G.O. No. 152 dated February 24, 1879.

Till the period when wildlife shooting was permitted, licensed hunters were allowed for a limited shoot. During that period game hunters from different places visited the forest after getting prior permission and had to pay for permits for particular animals (Shah 2003). After the enforcement of Wildlife (Protection) Act of 1972 such activities were totally banned and no body was allowed to hunt any wild species as it became an unbailable offence. That was the period when wildlife hunters with their friends and family used to go around in the forest and grassland area in search of trophies.

Rasiabadh Forest Rest House of the Conservation Reserve founded in 1889 is still an evidence of being used in past by the hunters.

The present Haridwar Forest Division came into existent in accordance with Government notification No. 2806/14.4.88-622/87 dated 31.3.89 as Social Forestry Division. Under the reconstitution of the Division certain areas like Haridwar Urban area in Roorkee-Lakhsar Range, Social Forestry Division Saharanpur and Khanpur-Pathri Ranges, were transferred from Shivalik Forest Division to Haridwar Forest Division. Later in 1994, an area of 22612.20 ha and 25 revenue villages of Bijnor Plantation Division were also transferred to Haridwar Forest Division. Earlier, the administrative control was under the Conservator of Forests, Meerut, Uttar Pradesh.

In the year 1994, Forest Ranges, namely, Chandi, Sabalgarh; Kotawali of Bijnor Plantation Forest Division was reconstituted as Shyampur and Chidiyapur Ranges.

In the year, 2000, as per the orders of Principal Chief Conservator of Forests, Uttarakhand, Letter No. 74/B.C/12.11.2000, the Forest Division was renamed as Haridwar Forest Division under the administrative control of the Chief Conservator of Forests, Garhwal, Shivalik Forest Circle, Dehradun.

The past history through earlier documents like working plans executed by the past officers clearly indicates that in the initial 70-80 years of the management history conservation and protection was not in the priority of forest managers. More emphasis was focused on forest working plans and systematic shikars by providing permits to the concerned rich parties. Most of the prescriptions and creation of working circles in the management plan were aimed at more exploitation, better yield of forest produce, creation of more shooting blocks and obtaining more revenue out of the forest wealth. Some of the presumption like removal of Mallotus trees, suppression of grasses, plantation of exotic trees like *Tectona grandis, Eucalyptus* hybrids*, Dalbergia sissoo* and *Acacia catechu* in grassy blanks inside the forest areas, were contrary to the Wildlife Conservation and contributed in wildlife habitat

destruction. Exploitation of timber and NTFP through forest contractors was another major cause of habitat destruction.

It was in the late sixties when forest managers realized the importance of conservation and wildlife protection and there was a shift of emphasis from exploitation and shikar towards the conservation and wildlife protection. Late in 1973's onward there was a shift and inclusion of wildlife conservation plan in the working plans (B.K.P.Sinha plan of 1973-89).

Notification of JJCR

On August 05, 2005 the government of Uttarakhand declared the area as a Conservation Reserve due to its ecological, faunal, floral, geo-morphological, natural, and zoological significance for the purpose of protecting, propagating, and developing wildlife and its environment (G.O.No. 2415/X-2-2005-21(5)/2005).

Current management

A management committee was constituted in the year 2005 under the chairmanship of CCF, Garhwal. It consists of CF, Shivalik Circle, Director, Rajaji National Park, President and Vice-President of Eco Development Committee, Tantwala, Dr.S.P.Sinha, Wildlife consultant, Joint Director, ZSI, Chief Agriculture Officer and District Livestock Officer of Haridwar, Dr.G.S.Rawat, WII and D.F.O, Haridwar Forest Division. It has a role of taking time to time management decisions.

A management plan oriented towards long-term conservation planning of swamp deer population has been prepared.

Chapter 4

Habitat Utilization

CHAPTER 4
HABITAT UTILIZATION

4.1 Introduction

Habitat is the place where an animal can live and reproduce. Food, water, cover, and space are basic requirements of an animal (Dasmann 1981). The extent of use of a habitat by an animal is determined largely by the extent to which the habitat can supply these requirements. Besides the basic requirements, there are other factors that influence the use of a habitat e.g. terrain, weather, human influences, and other animals (Schaller 1967, Eisenberg and Lockhart 1972, Sharatchandra and Gadgil 1975, Seidensticker 1976, Mishra 1982 cited in Putman 1988, Newton 1984, Bhatnagar 1991). All these factors ultimately determine the pattern (extent, purpose, time of day, duration, season, and strategy) of use of a habitat (Graf and Nichols 1966, Schaller 1967, Eisenberg and Lockhart 1972, Mishra 1982, Newton 1984).

Specific habitat requirements of species need to be determined for their effective management and conservation (Eisenberg and Seidensticker 1976, Ben-Shahar 1990). Many recent studies have concentrated on the associations between ungulates and their habitat components (e.g. Van Dyke et al 1983; Pratt et al 1986; Fox et al 1989; Ben-Shahar 1990). Ungulates are known to favour habitat types or vegetation communities where nutrient intake could be maximized (Westoby 1974; Owen-Smith and Novellie 1982; Owen-Smith 1985). Seasonal movements of large ungulates between different habitat types have also been well established (Bell 1971; McNaughton 1987). Ungulates especially the gregarious ones often respond to climatic changes and the resultant changes in the habitat by altering herd size and patterns of habitat utilization (McNaughton 1985). Inspite the subjectivity in selection of habitat categories, it is possible to identify the important factors that affect the extent of use of an area by an animal (Ben-Shahar 1990).

Martin (1977) studied barasingha of Kanha National Park and found that utilization pattern during the cool and dry season was found to be

governed by the availability of open rivulet zones and unburnt patches of grassland. During the growing season the barasingha were practically confined to tall grass areas along rivulets.

Singh (1984) did biological and ecological studies of swamp deer in Dudhwa and found that they preferred swampy or marshy open grassy forests. Mostly their concentration was high in the grassy patches near water holes. During dry season, when the wet soil was not available, they preferred sandy soil (soft soil). Their resting places were mostly sandy or moist areas where the shade of trees was available.

Qureshi et al (1995) studied habitat utilization by swamp deer in Dudhwa Tiger Reserve. In Dudhwa swamp deer utilized variety of habitat types including open forest where grasses were present, maximum abundance was observed in marshy and sandy grasslands (Schaller 1967, Martin `1975, Schaff 1978 and Singh 1984, Gopal 1995 and Qureshi et al. 1995).

Khan et al. (2004) studied habitat use of swamp deer in Dudhwa Tiger Reserve by direct and indirect methods. The data collected on various habitat parameters showed that swamp deer in Dudhwa Tiger Reserve prefer low grass height and high grass diversity.

The present study, conducted in Jhilmil Jheel Conservation Reserve aimed at understanding the pattern of habitat use by swamp deer and at identifying the factors that govern such a pattern.

Specific objectives were

- To study the way in which swamp deer use the habitat in the study area during various seasons and
- To identify the cover requirements during fawning season
- To identify the habitat parameters which are critical to its survival

4.2 Methodology

Two approaches have so far been used for quantification of habitat utilization. The first approach is based on the direct sighting, while the second based on indirect evidences e.g. pellet groups. Data on habitat utilization of swamp deer were collected by both direct and indirect methods. Since the data based on direct sighting reflect the habitat use only at the time of observation and thus a possible source of error occurred due to chance events and past disturbance. Therefore, in order to minimize this bias, data on habitat utilization of the swamp deer was also collected by indirect method.

4.2.1 Analysis based on direct sightings

In this approach only the major vegetation types which were recorded during the dawn to dusk observation were considered for analysis. These vegetation types represented the prominent habitat categories viz., swamp, agricultural fields, and dry grasslands (Plate 4.1-4.3). The other two habitat types viz. scrub forest and moist deciduous forest (Plate 4.4-4.5), in which direct observations could not be made but, were also utilized by the animals as indicated by indirect evidences i.e., pellet groups.

Availability and utilization of habitat

To estimate habitat availability, the vegetation type of utilized and available plots was determined and pooled together. During scan sampling, for each sighting the vegetation type within 10m radius of animal was recorded. Percentage utilization of each vegetation type was calculated by dividing the number of animals sighted in that vegetation type divided by the total number of animals seen in all vegetation types.

Data Analysis

Ivlev's electivity index (Ivlev 1961) was used to measure habitat selectivity, comparing the utilization of habitat with respect to its availability.

This index has been successfully used to determine food preferences in fallow deer (*Dama dama*) of Blue Mountains, Otago by Nugent (1988).

$E=u_i-a_i/\ u_i+a_i$

where u_i is the proportion of vegetation type i utilized and a_i is the proportion of this vegetation type that is available in the environment. Electivity indices measured the habitat selection in relation to their abundance or availability in the environment. The E values range from -1.0 to +1.0, with values between 0 and +1.0 indicating preference, values between 0 and -1.0 indicating avoidance, and values equal 0 indicating no selection. The χ^2-Square test was also performed to determine difference in animal use among different vegetation types.

Marcum-Loftsgaarden Analysis

In the Neu et al. (1974) analysis the expected habitat utilization is determined from measured map areas, i.e., there is no sampling error. This analysis therefore only takes into account the error caused in sampling the habitat utilization and not the error caused in sampling the habitat availability. Whereas, in the present study habitat availability has been estimated rather than determined exactly, as in the χ^2 goodness-of-fit test procedure. As a solution to this, Marcum (1980) came up with a nonmapping technique which took both the errors into account. It involved the use of a Bonferroni *z* statistic in conjunction with χ^2–square. χ^2-square tests the hypothesis that the animal uses vegetation categories in proportion to their availability (*H*: $a_i = u_i$). This hypothesis was then tested for homogeneity (Mendenhall 1971:299). The test statistic was $\chi^2 = \Sigma$ (observed – expected) ^{2}/expected.

When the hypothesis is rejected the conclusion is that the animal does not use each vegetation category in proportion to its occurrence. The next step is to determine which categories the animals prefer. This was done by obtaining 100(1-α)% simultaneous confidence intervals for $a_i - u_i$. Bonferroni's *z* statistics that determines the observations in the data that contribute most to the calculated χ^2-square value, and thereby evaluates whether a vegetation category is preferred, avoided, or used in proportion to availability. For

category *i*, if the confidence interval includes 0, $a_i = u_i$ and the category *i* was used in proportion to its availability. If 0 was not in the interval and both end points of the interval were positive, $a_i > u_i$ and and category *i* was used significantly less than in proportion to its availability (p=0.05). If 0 was not in the interval and both end points were negative, $a_i < u_i$ and category *i* was used significantly more than in proportion to its availability. The proportion of each vegetation type utilized and each vegetation type available was determined separately. Using the Bonferroni approach (Miller 1966), with $\alpha = 0.05$, 95% simultaneous confidence intervals for $a_i - u_i$ were constructed in each case. For $a_i - u_i$, a 95% confidence interval (Mendenhall 1971:193) was

$(a_i - u_i) \pm Z_{(1-\alpha/2k)} . [\, a_i(1- a_i) /n_1 + u_i(1- u_i)/n_2]^{1/2}$

where n_1 = number of plots, a_i and u_i are described above, n_2 = total number of animals sighted, α is the significance level (0.05) and k = number of categories.

4.2.2 Habitat use analysis based on indirect evidences

The pellet group method, reviewed by Neff (1968), Overton (1971), Putman (1984) has been used extensively for finding out habitat use of a number of ungulate species. This method was used for assessing habitat use of swamp deer in this study.

Availability and utilization of habitat:

Habitat selection by swamp deer was determined from observed usage in relation to the availability of various habitat variables. To determine the habitat availability data on habitat parameters (tree canopy cover, tree density, shrub height, shrub density, ground cover viz., grass, sedge, herbs and water) was collected from 50 permanent circular plots of 10m radius established at regular intervals within intensive study site. Data collected by intensive sampling (carried on either side of the trail at every 50m distance on all the trails) was also incorporated in this. This quantification was repeated in each season (monsoon, winter, summer) as some parameters change with season.

On the basis of year round utilization by swamp deer, 50 circular plots were laid representing all the habitats in the study site. These permanent plots were cleared before the onset of each season and counted for pellet groups at the end of each season to get a better picture of the overall seasonal utilization. Data on habitat parameters were collected as mentioned above.

Data Analysis

The number of pellet groups of swamp deer in each sampled plot was used to calculate pellet group density (pellet group/m^2) in each plot. Data from 50 plots were used in analyses. These values were pooled together to calculate mean pellet group density for swamp deer. To find out the correlation between pellet group densities of swamp deer with the habitat parameters, Pearson's product movement correlation coefficient was performed.

To determine habitat utilization pattern, used (randomly distributed) plots were compared with available (regular) plots located on either side of the trails. To find out differences between habitat variables of animal and regular plots, paired t-test was performed. The one way ANOVA was used to test for significant differences in mean pellet group densities vis-à-vis different habitat types, percentage grass/sedge/herbs etc.

To understand habitat use of swamp deer, data were subjected to Principal Component Analyses (PCA). Boxplot graphs were prepared to see the response of habitat utilization by the swamp deer to the presence/ absence of disturbance attributes and water bodies. All the quantitative data in the data matrix were transformed using log and Arcsine transformation function to improve normalcy in the data. Factor analyses were used to reduce the dimensionality of habitat variables. The first two factors which explained maximum variation in the data set were used for interpretation. All the statistical tests were performed using statistical package SPSS (Norusiss 1990).

4.3 Results

4.3.1 Habitat selectivity: Ivlev's index of habitat use

Ivlev's index for different vegetation types in different seasons is summarized in table 4.1. During monsoons, only *Typha* dominated patches were preferred whereas all other types were avoided. *Cyrtococcum accrescens*, *Mosla dianthera* patches were next followed by paddy field and *Phragmites karka* dominated patches.

In winters, both open patches (which were devoid of any vegetation) and *Typha* dominated patches were preferred in the same order and *Imperata cylindrica* dominated patches were avoided.

In summers, *Typha* dominated and *Carex myosurus* dominated areas were preferred in the same order while *Hygrophila polysperma* dominated patch and open patch avoided most, others avoided in the following sequence: *Mosla dianthera* dominated > *Imperata cylindrica* dominated > *Salix tetrasperma* dominated > *Phragmites karka* dominated areas (**see Plate 4.6 – 4.12**).

Table 4.1 Habitat selectivity and utilization in Jhilmil Jheel Conservation Reserve by swamp deer

Monsoons		Winters		Summers	
Vegetation type	**Ivlev's index**	**Vegetation type**	**Ivlev's index**	**Vegetation type**	**Ivlev's index**
Cyrtococcum accrescens	-0.84	*Imperata cylindrica*	-0.60	*Carex myosurus*	0.38
Mosla dianthera	-0.83*	Open patch	0.16*	*Hygrophila polysperma*	-0.92*
Paddy field	-0.16*	*Typha*	0.08	*Imperata cylindrica*	-0.72
Phragmites	-0.03*			*Mosla dianthera*	-0.86*
Typha	0.35			Open patch	-0.92
				Phragmites karka	-0.24*
				Salix tetrasperma	-0.54*
				Typha	0.96

*The values are close to 0 and will be interpreted statistically by Marcum's analysis

4.3.2 Marcum-Loftsgaarden analysis

For monsoons the test statistics calculated is 77.39. The critical χ^2-square value with significance level 0.05 and 4 df is 9.49. For winters the test

statistics calculated is 49.33. The critical χ^2-square value with significance level 0.05 and 2 df is 5.99. For summers the test statistics calculated is 643.63. The critical χ^2-square value with significance level 0.05 and 7 df is 14.07. The hypothesis of homogeneity is rejected for all the three seasons. Further, analogous confidence intervals for all $a_i - u_i$ of all categories in three seasons are summarized in tables below (Tables 4.2-4.4).

Table 4.2: Marcum-Loftsgaarden analysis for monsoons

Veg. types	No. Of plots	Proportion of plots (a_i)	Expected no. of plots	No. of animals sighted	Proportion of animals sighted	Expected no. of animals sighted	Confidence intervals		
							Lower bound	Upper bound	
C.a.	26	0.30	8.81	6	0.03	23.19	0.14	0.40	avoided
M.d.	8	0.09	2.75	2	0.01	7.25	0.00	0.16	used in proportion
P.f	18	0.21	14.32	34	0.15	37.68	-0.07	0.19	used in proportion
P.k.	2	0.02	1.93	5	0.02	5.07	-0.05	0.05	used in proportion
Typha	33	0.38	59.19	182	0.79	155.81	-0.57	-0.27	preferred
Total	87			229					

C.a. - Cyrtococcum accrescens
M.d. - Mosla dianthera
P.k. - Phragmites karka
P.f. - Paddy Field

Table 4.3: Marcum-Loftsgaarden analysis for winters

Veg. types	No. Of plots	Proportion of plots (a_i)	Expected no. of plots	No. of animals sighted	Proportion of animals sighted	Expected no. of animals sighted	Confidence intervals		
							Lower bound	Upper bound	
I.c.	23	0.22	6.65	118	0.06	134.35	0.07	0.27	avoided
O.p.	12	0.12	16.36	335	0.16	330.64	-0.12	0.03	used in proportion
Typha	68	0.66	80.00	1629	0.78	1617.00	-0.24	-0.01	preferred
Total	103			2082					

I.c. - Imperata cylindrica

O.p.- Open patch

Table 4.4: Marcum-Loftsgaarden analysis for summers

Veg. types	No. of plots	Proportion of plots (a_i)	Expected no. of plots	No. of animals sighted	Proportion of animals sighted	Expected no. of animals sighted	Confidence intervals		
							Lower bound	Upper bound	
C.m.	6	0.08	13.19	1497	0.17	1489.81	-0.18	-0.01	preferred
H.p.	6	0.08	0.29	27	0.00	32.71	-0.01	0.16	used in proportion
I.c.	33	0.42	5.62	607	0.07	634.38	0.20	0.51	avoided
M.d.	5	0.06	0.40	41	0.00	45.60	-0.02	0.14	used in proportion
O.p.	16	0.21	0.82	77	0.01	92.18	0.07	0.32	avoided
P.k.	10	0.13	6.12	687	0.08	690.88	-0.05	0.15	used in proportion
S.t.	1	0.01	0.31	34	0.00	34.69	-0.03	0.04	used in proportion
Typha	1	0.01	51.25	5838	0.66	5787.75	-0.69	-0.61	preferred
Total	78			8808					

C.m. - Carex myosurus
O.p.: Open patch
H.p. - Hygrophila polysperma
I.c. - Imperata cylindrica
M.d. - Mosla dianthera
P.k. - Phragmites karka
S.t. - Salix tetrasperma

4.3.3 Correlation analysis

The result of correlation analysis using Karl Pearson correlation coefficient for summer data showed statistically significant positive correlation between mean pellet group density of swamp deer and hydrophyte cover ($r=0.656$, $P<0.05$). However, the pellet group density showed negative correlation with shrub height ($r=-0.355$, $P<0.05$), shrub density ($r=-0.311$, $P<0.05$), grass cover ($r=-0.305$, $P<0.05$) and herb cover ($r=-0.494$, $P<0.05$). The pellet group density also showed negative correlation with high canopy cover, tree density, pteridophyte cover, and sedge cover but were not statistically significant.

Monsoon data showed significant positive correlation between mean pellet group density of swamp deer and hydrophyte cover ($r=0.670$, $P<0.05$). However, the pellet group density showed significant negative correlation with grass cover ($r=-0.586$, $P<0.05$). The pellet group density also showed negative correlation with tree canopy, tree density, shrub height, shrub

density, pteridophyte cover and positive correlation with herb cover and sedge cover but were not statistically significant.

Winter data showed significant positive correlation between mean pellet groups of swamp deer and hydrophyte cover ($r=0.598$, $P<0.05$) and sedge cover ($r=0.619$, $P<0.05$). However, the pellet group density showed significant negative correlation with tree canopy ($r=-0.313$, $P<0.05$), shrub density ($r=-0.375$, $P<0.05$), grass cover ($r=-0.310$, $P<0.05$) and herb cover ($r=-0.308$, $P<0.05$). The pellet group density also showed negative correlation with tree density and shrub height but were not statistically significant (Table 4.5).

Table 4.5 Correlation between mean pellet group densities of swamp deer with different habitat parameters

Habitat parameters	Correlation value		
	Summer	Monsoon	Winter
Tree canopy	-0.274	-0.210	-0.313
Tree density (per ha)	-0.249	-0.221	-0.266
Shrub height	-0.355	-0.241	-0.256
Shrub density (per ha)	-0.311	-0.267	-0.375
Grass cover	-0.505	-0.586	-0.310
Herb cover	-0.495	0.096	-0.308
Hydrophyte cover	0.656	0.670	0.598
Pteridophyte cover	-0.114	-0.090	0.000
Sedge cover	-0.008	0.254	0.619

4.3.4 Seasonal variation in habitat parameters

Independent sample t test was performed to find out difference between mean pellet group density, tree canopy cover, tree density, shrub height, shrub density, grass cover, herb cover, hydrophyte cover, pteridophyte cover, and sedge between used and available plots in summer season. The results showed that mean pellet group density ($t = 0.000$, d.f. = 192, $P<0.05$), tree density ($t = 0.032$, d.f. = 192, $P<0.05$), herb cover ($t = 0.000$, d.f. = 192, $P<0.05$) and hydrophyte cover ($t = 0.000$, d.f. = 192, $P<0.05$) differed significantly across used and available plots. However the tree canopy cover, shrub height, shrub density, grass cover, pteridophyte cover, and sedge cover did not differ significantly between used and available plots (Table 4.6).

The results of t test for monsoon season showed that tree canopy cover (t = 0.035, d.f. = 192, P<0.05), tree density (t = 0.022, d.f. = 192, P<0.05) and grass cover (t = 0.018, d.f. = 192, P<0.05) differed significantly across used and available plots. However the mean pellet group density, shrub height, shrub density, herb cover, hydrophyte cover, pteridophyte cover, and sedge cover did not differ significantly between used and available plots (Table 4.7).

The results of t test for winter season showed that none of the habitat variables differed significantly between used and available plots (Table 4.8).

Table 4.6 Paired t-test between habitat variables of used and available plots in the study area in summer season

Variable	Used Plots (Mean)	Available Plots (Mean)	Mean difference	t value	Sig.
Pellet group density	5.72	1.67	4.053 (±0.505)	8.025	0.000*
Tree canopy cover	4.20	9.54	-5.342 (±2.811)	-1.900	0.059
Tree density per ha	10	50	-40 (±0.002)	-2.164	0.032*
Shrub height	0.36	0.30	0.058 (±0.101)	0.572	0.568
Shrub density per ha	1000	600	400 (±.028)	1.343	0.181
Grass cover	28.93	28.85	0.071 (±5.419)	0.013	0.990
Herb cover	6.2750	27.743	-21.46806 (±3.935)	-5.455	0.000*
Hydrophyte cover	18.175	5.799	12.3764 (±2.328)	5.316	0.000*
Pteridophyte cover	0.08	0.15	-0.073 (±0.132)	-0.549	0.584
Sedge cover	6.400	7.873	-1.473 (±2.058)	-0.716	0.475

Table 4.7 Paired t test between habitat variables of used and available plots in the study area in monsoon season

Variable	Used plots (Mean)	Available plots (Mean)	Mean difference	t value	Sig.
Pellet group density	0.82	0.92	-0.097 (±0.566)	-0.171	0.865
Tree canopy cover	4.54	11.82	-7.280 (±3.434)	-2.120	0.035
Tree density per ha	60	100	-40 (±0.002)	-2.317	0.022
Shrub height	0.39	0.36	0.026 (±0.106)	0.246	0.806
Shrub density per ha	2100	2700	-600 (±0.085)	-0.748	0.455
Grass cover	40.83	50.88	-10.054 (±4.212)	-2.387	0.018
Herb cover	20.0350	15.6389	4.39611 (±2.881)	1.526	0.129
Hydrophyte cover	13.13	9.36	3.767 (±2.750)	1.370	0.172
Pteridophyte cover	0.15	0.17	-0.024 (±0.158)	-0.149	0.882
Sedge cover	15.4400	14.8576	0.58236 (±2.702)	0.216	0.830

Table 4.8 Paired t test between habitat variables of used and available plots in the study area in winter season

Variable	Used plots (Mean)	Available plots (Mean)	Mean difference	t value	Sig.
Pellet group density	6.82	6.40	0.417 (±0.775)	0.538	0.591
Tree canopy cover	3.62	8.06	-4.439 (±2.517)	-1.764	0.079
Tree density per ha	50	200	-150 (±0.017)	-0.924	0.357
Shrub height	0.23	0.37	-0.137 (±0.100)	-1.362	0.175
Shrub density per ha	900	1300	-400 (±0.052)	-0.771	0.442
Grass cover	32.350	30.913	1.4368 (±5.194)	0.277	0.782
Herb cover	16.6000	13.3420	3.25799 (±1.959)	1.663	0.098
Hydrophyte cover	10.43	8.17	2.257 (±1.910)	1.182	0.239
Pteridophyte cover	0.00	0.09	-0.089 (±0.121)	-0.729	0.467
Sedge cover	14.0500	11.4323	2.61771 (±2.189)	1.195	0.233

4.3.5 Relative use of habitats

The results of 1-way ANOVA showed that mean pellet group densities differ significantly among different habitat types in all the seasons (p=0.000, df=4, F=15.331), (p=0.006, df=4, F=3.702) and (p=0.000, df=4, F=35.491) respectively (Tables 4.9, 4.10 and 4.11).

Table 4.9 The results of ANOVA for difference in mean pellet group densities among different habitat types in summers

Source	Type III Sum	df	Mean Square	F	Sig.
Corrected Model	594.778(b)	4	148.694	15.331	.000
Intercept	570.309	1	570.309	58.803	.000
Habitat	594.778	4	148.694	15.331	.000
Error	1833.057	189	9.699		
Total	**3854.000**	**194**			
Corrected Total	**2427.835**	**193**			

a. Computed using alpha = 0.05
b. R Squared = .245 (Adjusted R Squared = .229)

Table 4.10 The results of ANOVA for difference in mean pellet group densities among different habitat types in monsoons

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	65.662(b)	4	16.415	3.702	.006
Intercept	25.676	1	25.676	5.790	.017
Habitat	65.662	4	16.415	3.702	.006
Error	838.174	189	4.435		
Total	**1002.000**	**194**			
Corrected Total	**903.835**	**193**			

a. Computed using alpha = 0.05
b. R Squared = .073 (Adjusted R Squared = .053)

Table 4.11 The results of ANOVA for difference in mean pellet group densities among different habitat types in winters

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1840.006(a)	4	460.001	35.491	.000
Intercept	4440.163	1	4440.163	342.576	.000
Habitat	1840.006	4	460.001	35.491	.000
Error	2501.494	193	12.961		
Total	**12707.000**	**198**			
Corrected Total	**4341.500**	**197**			

a. Computed using alpha = 0.05
b. R Squared = .424 (Adjusted R Squared = .412)

4.3.6 Factors governing habitat use

The PCA performed on the habitat parameters of utilized and available plots extracted three components accounting a total cumulative variance of 67.4% in summers. Out of three extracted principal component system, PCI accounted for 37.2% of variance and PCII accounted for about 18.4% of variance. The two components together explained 55.6% of total variance (Table 4.12). The PC I was positively correlated with tree canopy cover, shrub height and herb cover whereas hydrophyte cover showed highest negative correlation. The sedge, hydrophyte, and herb cover showed positive correlation and grass cover showed highest negative correlation with PC II. The distribution of pellet groups in relation to first and second components is shown in figure 4.1. It indicates that swamp deer prefer habitat with open canopy, low shrub density, good sedge, and hydrophyte cover.

During monsoon season the first two components accounted for 51.9% of variation in data matrix (Table 4.13). The figure 4.2 shows the distribution of pellet groups in relation to first and second component. The first factor is highly positively correlated with shrub density, tree canopy cover, and pteridophyte cover but highly negatively correlated with sedge cover. Second factor was positively correlated with herb, hydrophyte and sedge cover. During monsoons, swamp deer hardly utilized wooded areas and restricted itself to open grassland. While PC1 was the ‘woodland factor’ (strongly related

to tree and shrub attributes), PC2 was the 'grassland factor' as it had strong relation with ground covers.

Table 4.14 provides the component loading for PCA performed on habitat parameters in winters. During winters the first two factors accounted for 53.1% of the variation in data set. The first factor was highly positively correlated shrub height, tree canopy cover, and grass cover. The second factor was highly positively correlated with tree canopy cover, shrub density and hydrophyte cover. The pellet groups were plotted against first and second factor (Fig. 4.3). In winters, while PC1 represented same woodland component, PC2 was a component mix of both wooded areas and open grassy meadows as it had strong relations with both set of attributes.

Table 4.12 Principal component analyses of habitat variables of utilized and available plots showing component loadings during summers

Variables	PCI	PCII	PCIII
Tree canopy cover	.894	.034	.069
Shrub height	.806	-.069	-.161
Tree density per ha	.788	.128	.156
Shrub density per ha	.781	-.031	-.140
Herb cover	.699	.345	-.076
Grass cover	-.110	-.911	-.003
Sedge cover	-.308	.582	.263
Hydrophyte cover	-.367	.522	-.094
Pteridophyte cover	.165	-.127	.931
% of variance	37.213	18.415	11.728
Cumulative variance	37.213	55.628	67.356

Table 4.13 Principal component analyses of habitat variables of utilized and available plots showing component loadings during monsoons

Variables	PCI	PCII	PCIII
Shrub density per ha	.877	.187	-.017
Tree canopy cover	.855	.022	.303
Shrub height	.837	.107	-.114
Tree density per ha	.745	.123	.449
Grass cover	.177	-.934	-.197
Herb cover	.102	.688	-.438
Hydrophyte cover	-.424	.458	.036
Sedge cover	-.457	.272	.522
Pteridophyte cover	.290	.170	-.520
% of variance	31.933	20.044	15.498
Cumulative variance	31.933	51.977	67.476

Table 4.14 Principal component analyses of habitat variables of utilized and available plots showing component loadings during winters

Variables	PCI	PCII	PCIII
Shrub height	.821	.286	.128
Sedges cover	-.725	.301	-.025
Tree canopy cover	.719	.527	-.047
Hydrophyte cover	-.718	.442	.032
Shrub density per sqm	.708	.457	.075
Grass cover	.552	-.674	-.121
Herb cover	-.225	.422	.113
Pteridophyte cover	.134	-.112	.898
Tree density per sqm	.380	.211	-.389
% of variance	29.311	23.826	11.359
Cumulative variance	29.311	53.136	64.495

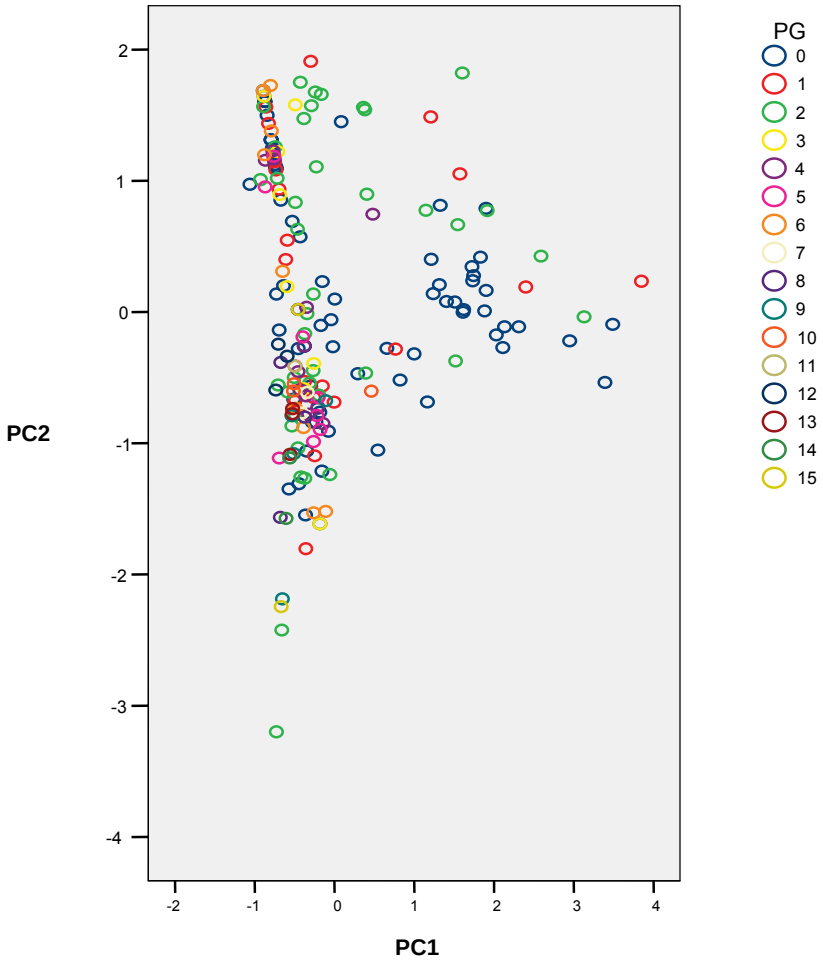


Figure 4.1 Ordination of pellet groups (PG) along first two components during summers

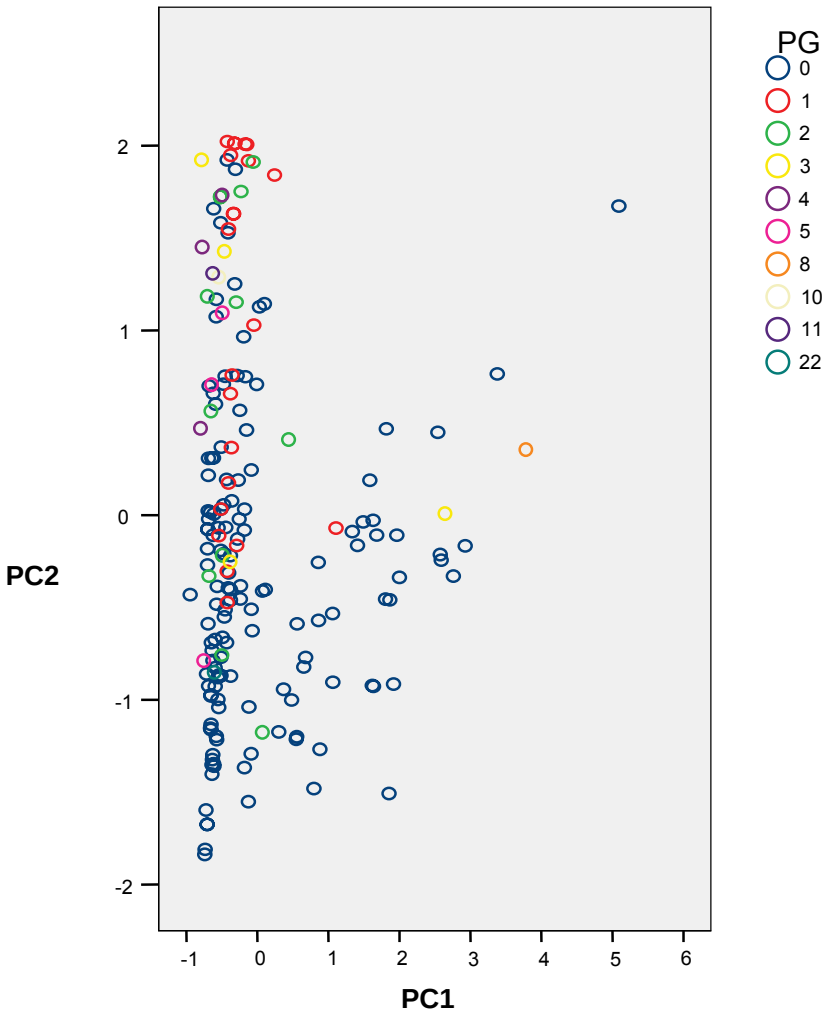


Figure 4.2 Ordination of pellet groups (PG) along first two components during monsoons

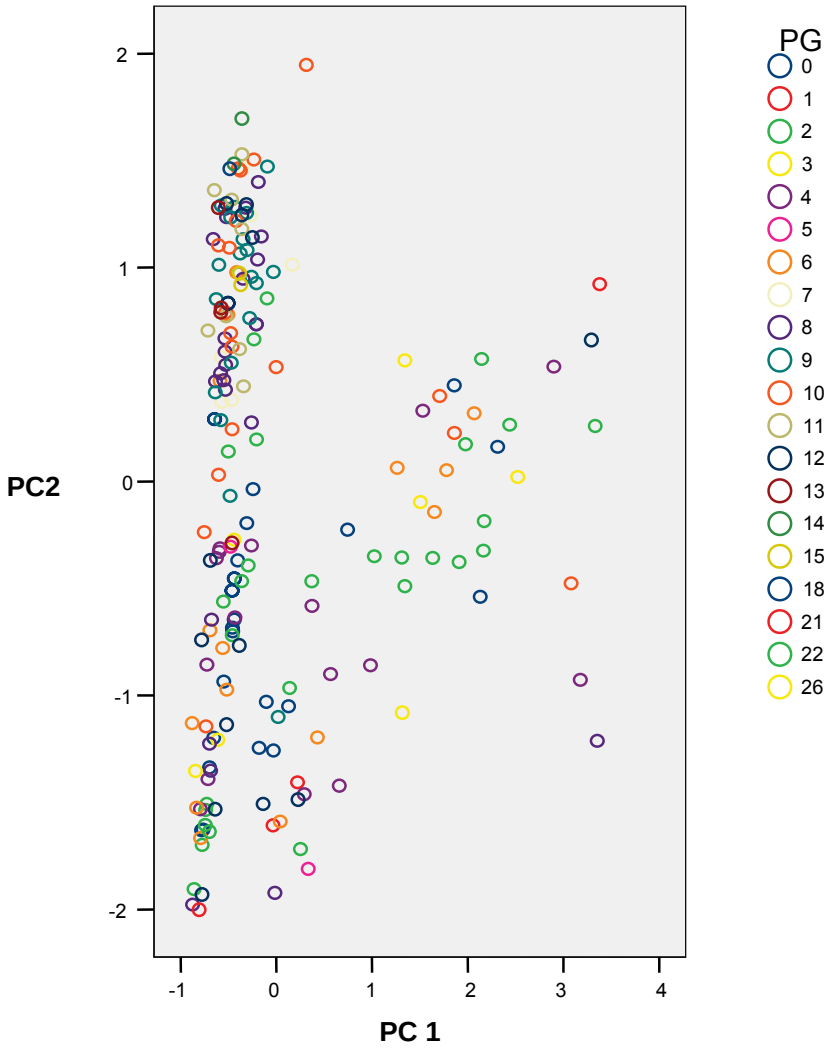


Figure 4.3 Ordination of pellet groups (PG) along first two components during winters

Since there was a general agreement in the response of swamp deer to disturbance factors and water bodies in the three seasons, these are being presented together. Boxplot graphs clearly indicate that swamp deer avoids areas with livestock or human and prefer staying near streams (Fig. 4.4-4.9).

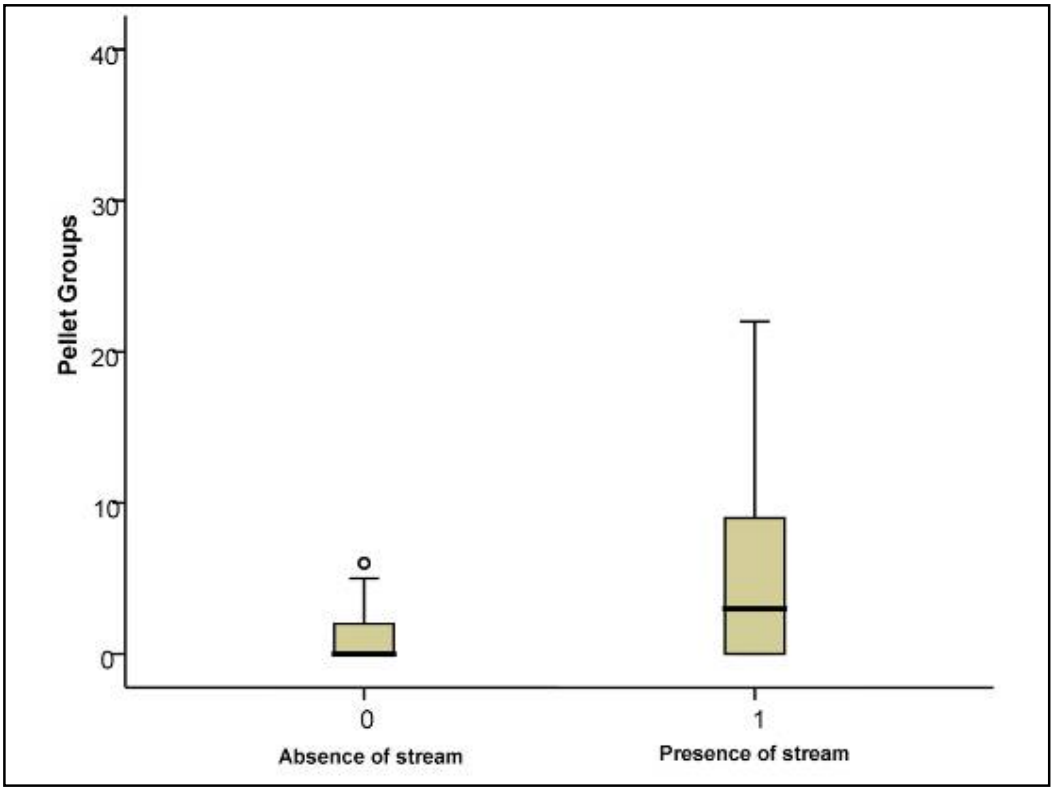


Figure 4.4 Boxplot plot diagram showing response of swamp deer to stream

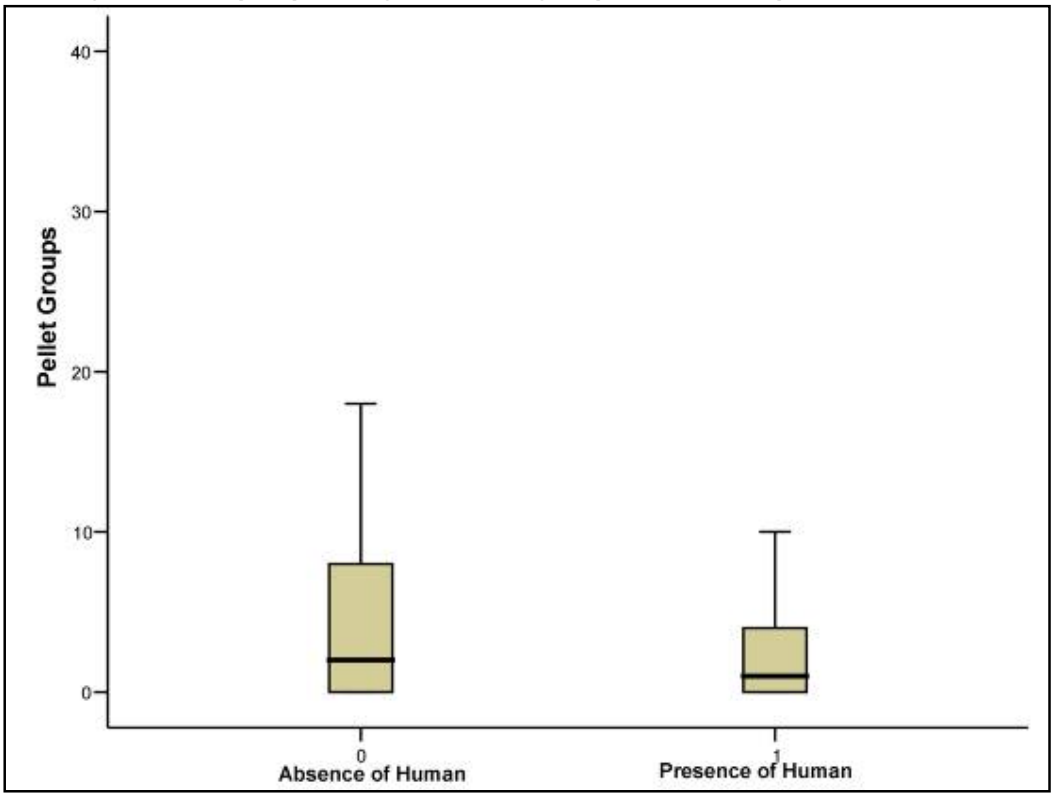


Figure 4.5 Boxplot plot diagram showing response of swamp deer to humans

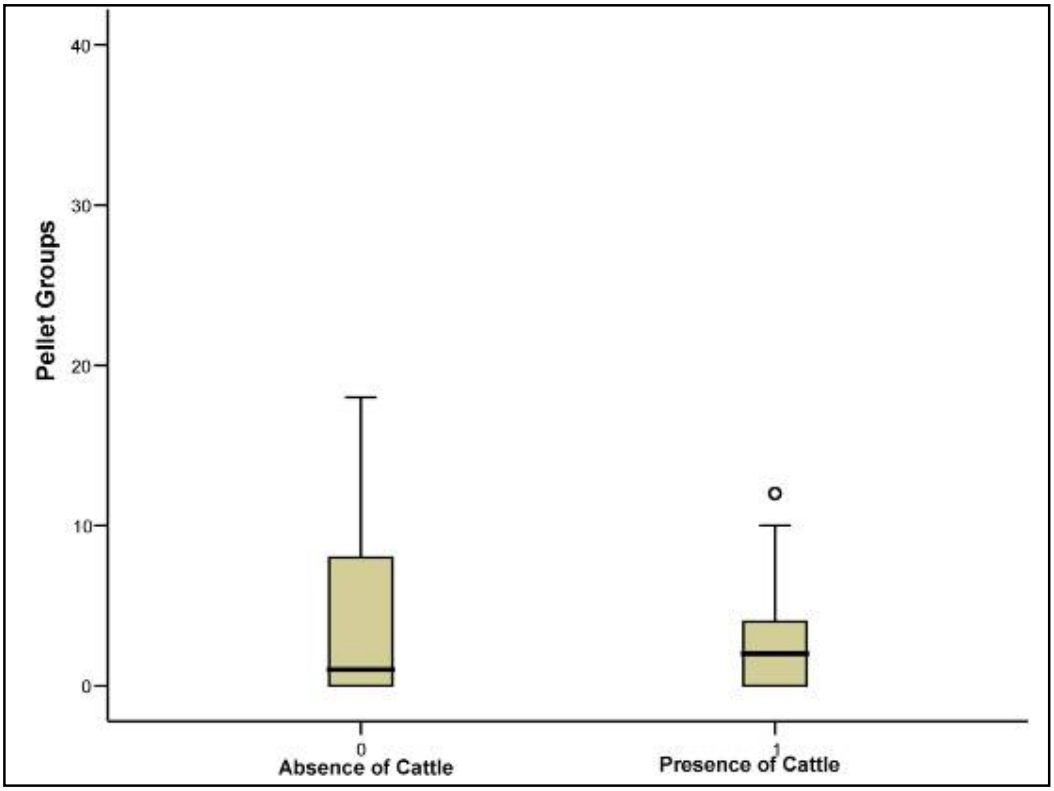


Figure 4.6 Boxplot plot diagram showing response of swamp deer to cattle

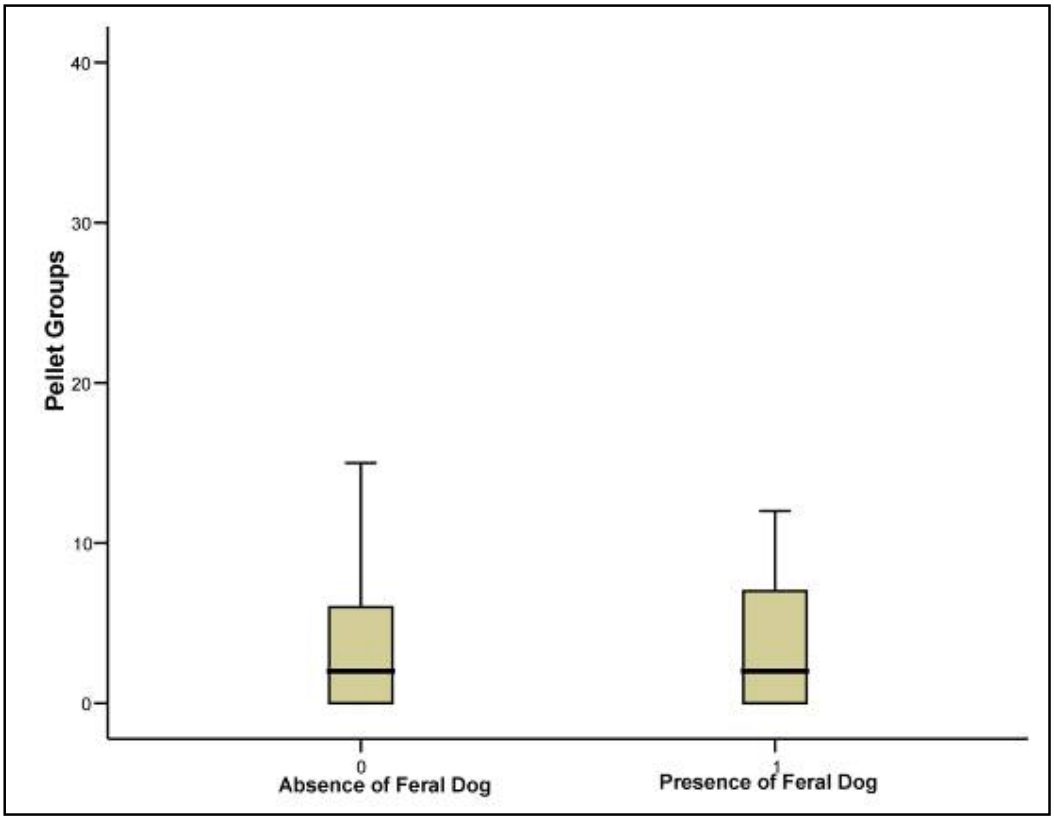


Figure 4.7 Boxplot plot diagram showing response of swamp deer to feral dog

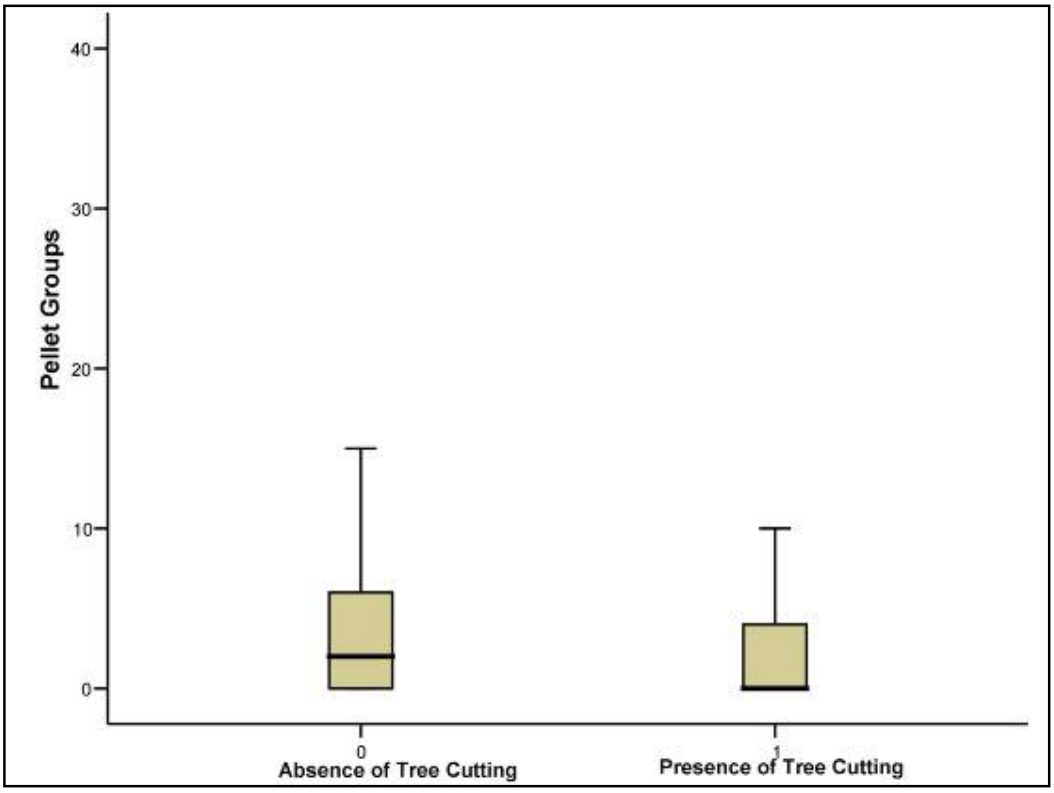


Figure 4.8 Boxplot plot diagram showing response of swamp deer to tree cutting

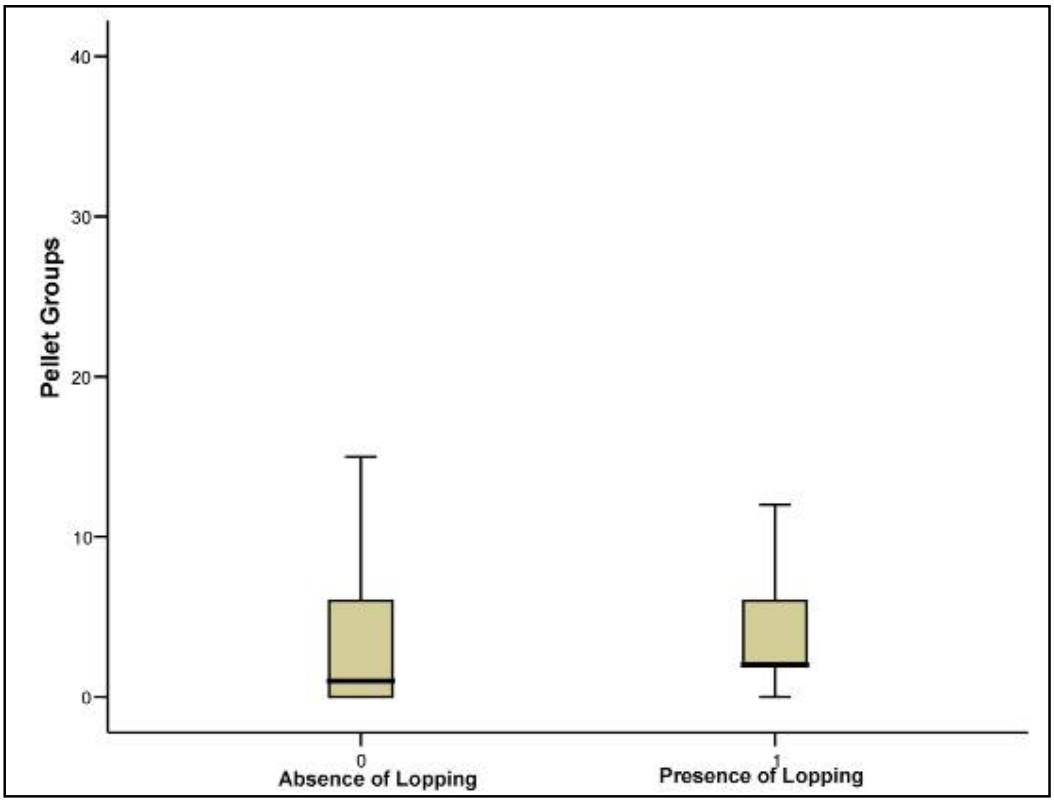


Figure 4.9 Boxplot plot diagram showing response of swamp deer to lopping

4.4 Discussions

The study on habitat use by swamp deer in Jhilmil Jheel Conservation Reserve was carried by direct and indirect methods. Both techniques have been used extensively by various workers (e.g. Eberhardt and Van Etten 1956, Rogers *et. al*. 1958, Martinka 1968, Short *et al.* 1977, Green 1985, Khan 1993) to investigate the habitat use of different ungulate species in India and outside. The studies carried out so far provide substantial evidence that both approaches are equally useful in exploring ungulate-habitat relationship provided a good sampling design is used and observer's errors are reduced.

4.4.1 Direct method

Monsoon forms the most active time of feeding for swamp deer and their requirement is a dense hiding cover while feeding which is met (best) by *Typha* spp. dominated patches and none others. Vegetation cover of the habitat is an important determinant of the antipredator strategies of ungulates (Geist 1974, 1987). Inhabitants of dense cover assume a hiding strategy to escape from predators (Geist 1974; Schaller 1977, 1980). Thick cover of *Typha* spp. also meets the cover requirement for the newly borns and the lactating females.

Winter forms the rutting period for swamp deer, and their requirements are sparring, basking, and foraging grounds. Open patches solve only the former two purposes while *Typha* spp. dominated patches meet all the three requirements. In addition to this, females preferably use *Typha* spp. dominated patches only.

In summers *Carex myosurus* dominated areas are preferred for feeding, resting, wallowing, and drinking water while *Typha* spp. dominated areas are preferred for feeding, resting, and thermal cover. Other vegetation types do not meet all the requirements to this extent. Summer also form the pinch period in the life cycle of the animal as all the covers required deplete (chapter 8). It therefore forms the deciding factor in their life cycle.

Swamp deer require a habitat that provides ample escape cover. When threatened, they take refuge in thick vegetation (pers. obs.). This is the other reason (the major being food availability) why *Typha* spp. dominated vegetation type is preferred in all the seasons. It is noteworthy here that the study site is a habitat island amidst a mosaic of human dominated landscape.

4.4.2 Indirect method

A pellet group is an indicator of presence of animal in any given vegetation type and has been used as standard method to study the habitat preference of ungulates by different workers (Khan 1989, Khan 1993, Ilyas 2001). The data based on indirect evidences i.e. pellet groups has been analyzed in a variety of ways. The pellet group density of swamp deer show positive correlation with hydrophyte cover in all the three seasons. It is actually *Typha* spp. which as mentioned above serves multipurpose of various cover requirements. On contrast, it showed negative correlation with grass cover round the year as they avoided short grasslands for the fear of absence of hiding cover and tall grassland (primarily *Phragmites karka*) due to their coarseness. Other workers like Khan (1989) and Khan (1993) have also reported negative correlation of mean pellet group densities with grass height in Dudhwa Tiger Reserve. Qureshi et al. (1995) reported highest percent occurrence of swamp deer pellets in *Imperata cylindrica-Vetiveria zizanioides-Saccharum spontaneum* association throughout the year in Dudhwa Tiger Reserve. Banerjee (2001) reported swamp deer using short grasslands during summer and winter in Kaziranga National Park.

Animals range within their habitat to obtain food, reproduces, and takes care of their young and to minimize chance of getting preyed upon. Therefore, in order to enhance their inclusive fitness, swamp deer should select habitats with an optimal availability of food and structural resources that maximize their survival.

The habitat variables recorded in this study can be grouped into those related to ‘security’ (hiding cover, distance from livestock), food, and cover which were revealed by factor analyses on the utilization data.

The data collected on various habitat parameters showed that swamp deer in Jhilmil Jheel Conservation Reserve prefer areas high in hydrophyte cover and avoid areas high in grass cover.

Plate 4.1 Swamp

Plate 4.2 Waterlogged fields

Plate 4.3 Dry grassland

Plate 4.4 Scrub forest

Plate 4.5 Moist deciduous forest

Plate 4.6 *Typha* patch

Plate 4.7 Paddy field

Plate 4.8 *Phragmites* patch

Plate 4.8 *Hygrophila polysperma*

Plate 4.9 Tree patch

Plate 4.11 Open patch

Plate 4.12 *Imperata cylindrica* patch

Chapter 5

Food Habits

CHAPTER 5
FOOD HABITS

5.1 Introduction

It is important to understand the food habits of a species, in terms of food preference and availability, for the evaluation and management of its habitat (Nelson and Leege 1982, Norton 1984). Riney (1982) has discussed the relevance of food habit studies in making management decisions. Forage quality has been found to be an important determinant of habitat use by herbivores. Physical structure and growth phase of the food species and their seasonal variation are of vital importance to ungulates. All animals are known to selectively feed on more palatable and nutritious species compared to coarse and less digestible species (Gwynne and Bell 1968, Bell 1970, 1971). Tolerance to low quality forage depends on the body size and gut physiology of the ungulates.

Grzimek and Grzimek (1960) were the first to recognize that neither all areas nor all grass species are used by ungulates. Chemical analysis reveals that the preferred food species in case of most of the herbivores have higher protein and digestibility and this is strongly influenced by season (Putman 1996). Most herbivores have to compromise on food, in the process of predator avoidance (Festa-Bianchet 1988). In Jhilmil Jheel Conservation Reserve, though the natural predation on swamp deer seems to be very low but the humans have always played role of an exterminator. The concept of optimal foraging (MacArthur and Pianka 1966) accounts for the various factors that affect the diet of an animal. The optimality of a diet can be measured in terms of the net amount of energy gained in obtaining a food item, in comparison to the energy spent in searching for it, which is cost-benefit ratio of obtaining a particular food item. The value of a food item is determined by its nutritional value relative to the costs of acquiring it (MacArthur and Pianka 1966). In more productive environments, or during more productive seasons, animals may consume greater biomass per unit time but, they usually have greater choice and more restricted diet in terms of the number of species i.e., they show high preferences for a fewer species

only. Ungulate diet selection, foraging behaviour, feeding ecology and plant community structure can be related to the body size, morphology and physiology (Jarman 1974).

Based on feeding behaviour, grassland herbivores can be classified into generalist feeders like rhinoceros which require an abundant supply of food, though relatively poor in quality, and selective feeders such as hog deer which require smaller quantities but fresh, nutritious and highly palatable grasses.

There are several methods which can be employed in food habits studies. However, none of these methods is without weaknesses. Stewart (1967) advocated for the faecal analysis method, and mentioned the possibility of applying correction factors to account for differential digestibility.

The selection of methods depends on the detailed requirement of the study, and the feasibility in terms of the proximity to the animal. Direct observation and quantification of bites, oesophageal fistula, quantification of feeding signs, rumen analysis, and faecal analysis are some of the more commonly used methods in feeding studies of ungulates. This chapter deals with the food habits of swamp deer in Jhilmil Jheel Conservation Reserve, in Haridwar Forest Division, Uttarakhand. The chapter deals with the following sub-objectives:

- To document and quantify the availability and utilization of plant species in the study area during different seasons
- To establish plant species constituting seasonal diets of swamp deer
- To determine preferences of food plant species by swamp deer
- To compare and evaluate methods used for food habit studies, with reference to swamp deer

5.2 Methodology

For the purpose of food habit analysis the year was divided into the three seasons viz., summer, monsoon and winter. Data analysis and

discussion on seasonal changes in vegetation and subsequent change in feeding pattern of swamp deer are presented accordingly. Seasonal break up of various months is as follows:

Summer: 16 February – 15 June

Monsoon: 16 June – 15 October

Winter: 16 October – 15 February

Commencement of summer and arrival of monsoon marked the drastic changes in plant phenology and vegetative growth. Most of the plant species attain maximum biomass by monsoon. This was the season in which there was highest diversity of food plants. Late monsoon had maximum flowering and fruiting. Senescence of vegetation set in winter, limiting the availability of forage to swamp deer. The following methods were used to study the food habits of swamp deer:

(i) Direct observations

Focal animal sampling (Altman 1974) was followed on same schedule as scan animal sampling (chapter 6). Each bite of the animal, and the species that it was consuming, was recorded. Chi- square test was performed to see the variation in frequency distribution of different food plants selected among different age and sex categories and among seasons within categories.

(ii) Quantification of feeding

This is one of the indirect methods of studying the feeding of ungulates, and is especially useful in case of shy species which cannot be approached without causing disturbance and change in their behaviour due to the presence of the observer. Apart from quantifying utilization by the species being studied, this gives an index of availability in the feeding area.

The feeding sites were examined, after the animal left the location, for fresh feeding signs and identification of plants fed by the animal. Identification of plants in the field was done with the help of floras, research papers and reports (e.g., Mason et al 1996, Babu 1997, Gaur 1999, Khan 1987, 2002, 2003). Unidentified plants were collected and preserved following Jain and

Rao (1997) and brought to Wildlife Institute of India (WII) Dehradun for further examination and identification. Herbarium of WII was consulted to cross check the identity of various species. A set of duplicate specimens were collected for less known and unidentifiable species preserved at WII's herbarium. Field notes were made on each species *viz*., local names, habit, habitat, flowering period, general availability and local use using a standard field note book.

Food preference was estimated through feeding quadrat method (Grobler, 1981 and 1983). The plots were selected at random and the number varied depending upon the size of the area used by the animal at the time of observation. Plots of 1x1 m (for grass and herbs) and 5 x 5 m (for shrubs) were laid at fresh feeding sites located while observing. All the food plants species within the plots were listed. The number of food species (grass, herb and sedge), the percentage cover of each species and the phenology of available and utilize species were recorded in each habitat type.

Data analysis

The principal food was worked out for grass, herb and sedge separately, in each group in different habitat types. The major habitat types identified for the purpose were swamp, scrub forest, dry grassland, agricultural fields and moist deciduous forest.

Ivlev's electivity index (Ivlev 1961) was used to measure feeding selectivity, comparing the utilization of food with respect to its availability. Ivlev's index is defined as:

$E=u_i-a_i/ u_i+a_i$

where u_i is the proportion of food type i consumed and a_i is the proportion of this food type that is available in the environment. The E values range from -1.0 to +1.0, with values between 0 and +1.0 indicating preference, values between 0 and -1.0 indicating avoidance, and values equal 0 indicating no selection. The Chi-Square test was also performed to determine difference in seasonal food preferences.

Marcum-Loftsgaarden analysis

Marcum-Loftsgaarden analysis was preferred over Neu et al's. It involved the use of a Bonferroni *z* statistic in conjunction with chi–square. Chi-square tests the hypothesis that the food species are utilized in proportion to their availability (*H*: $a_i = u_i$). This hypothesis was then tested for homogeneity (Mendenhall 1971:299). For $a_i - u_i$, a 95% confidence interval (Mendenhall 1971:193) was

$(a_i - u_i) \pm Z_{(1-\alpha/2k)}.[\, a_i(1- a_i) /n_1 + u_i(1- u_i)/n_2]^{1/2}$

where a_i = proportion availability of food category *i*, u_i = proportion utilization of food category *i*, n_1 = number of plots in which food type *i* is available, n_2 = number of plots in which food type *i* is utilized, α is the significance level (0.05) and k = number of categories.

Microhistological analysis of faecal pellets

This is another very widely used method (e.g. Stewart 1967, Todd and Hansen 1973, Green 1987). Its advantage over the examination of feeding sites is that even species consumed in small proportions would be recorded. Such species, which are usually small plants, tend to be overlooked at feeding sites, either because they are totally consumed and do not leave any sign of their presence on the ground, or because they grow in close proximity of a bigger plant, and are therefore not recorded. The disadvantage of this method is that the proportions of some plants are over represented, while those of some others are under-represented, due to differential digestibility.

The method involves two major steps. First, the preparation of reference material of the food plant species for the identification of epidermal and cellular characteristics of the species, and second, the microhistological examination of faecal material, to estimate the frequency of fragments of various plant species. Plant material was collected in the field, air dried and then stored in paper bags, for later transportation to the laboratory. The plant material was separated by part, i.e. leaf, stem, flower. This material was ground to a fine powder (to fit a 1 mm mesh).

A small quantity of the powdered material was left overnight in 6% hydrogen peroxide, to partially remove pigments, which would otherwise obscure characteristic epidermal and cellular patterns of the species. The material was then washed through a fine sieve under running water to remove traces of hydrogen peroxide. Further, this bleached material was air dried. A slide was then prepared of this plant material with DPX mounting medium. The slide was left to dry, until the mounting medium hardened. In the same way, slides were prepared for each of the plant species collected. The slides were viewed under a microscope at 100X magnification, and characteristic epidermal patterns were identified and a diagram was made for each characteristic pattern, for later comparison with fragments found in faecal material. Reference slide of 42 plant species and their parts were made, based on initial field identification of food species.

Fresh faecal pellets of swamp deer were also collected on a monthly basis and later combined by season, for analysis of seasonal food habits of swamp deer. Pellets were collected from all the five habitat types, of six individuals in each habitat. The faecal material was also air-dried in the field, and stored in labelled paper bags. In the laboratory, faecal pellet composites were made of each pellet group. This material was then prepared for microhistological analysis in the same way as the plant material. Six slides were prepared for each habitat, that is, a sample of 30 slides for each month, 120 for each season and 360 for a year.

A few assumptions underlie the procedure (Johnson 1982): (i) The plant fragments are randomly distributed on the slide, (ii) The fragments are of equal size, and (iii) dry weight densities of different plant species are equal. Twenty microscope fields are examined on each slide, and all the identifiable fragments in these fields were recorded. The percent of each species constituting the diet was determined by dividing the number of identifiable fragments of each species by the total number of identifiable fragments, and multiplying by 100, following Sparks and Malechek (1968).

Seasonal differences in consumption of the major species were examined statistically, using the chi-square (Siegel 1956).

Forage availability

The biomass of food species of swamp deer, identified through direct observation was measured through clip and weigh method (Wiegert, 1962). A total number of 30 quadrats of 1mX1m size were laid in different habitats. All the food species were clipped and weighed in the field and sub samples were oven dried at 60°C constant temperature till the samples reached constant weight. Biomass of each individual species was calculated. Food species were grouped into grass, herb, sedge and aquatic plants. The total of these four groups were taken as total food available. Such data were collected for three seasons. The data were grouped for habitat wise biomass.

The results of biomass estimates for habitats were subjected to two way ANOVA for testing the significant effect of habitat and season on biomass.

5.3 Results

Age and sex categories as a whole and male, female, adult, and sub adult across seasons showed no significant variation in feeding habits. Yearling and fawn showed significant differences in feeding habits across seasons (Table 5.1).

Table 5.1 Chi square test values for variation in frequency distribution of different feeding habits between different age and sex categories and between seasons within categories

Categories	χ^2 Value	P value
Age	32.938	0.000
Sex	38.635	0.000
Male	149.073	0.000
Female	40.137	0.000
Adult	61.923	0.000
Sub adult	122.422	0.000
Yearling	14.646	0.023
Fawn	1.190	0.551

5.3.1 Food species

Table 5.2 gives the list of plant species fed by swamp deer in Jhilmil Jheel Conservation Reserve. It was observed to feed on 42 species of plants belonging to 15 families. More than 75% of the food species were of the family Poaceae (16 species), Cyperaceae (5 species), Fabaceae (5 species),

Asteraceae (4 species) and Typhaceae (2 species). Plants from the families of Poaceae and Cyperaceae combinedly formed the major food item of swamp deer in the area.

Table 5.2 Food species of swamp deer in Jhilmil Jheel Conservation Reserve

Species	Family
Coix lachryma-jobi	Poaceae
Cynodon dactylon	Poaceae
Cyrtococcum accrescens	Poaceae
Echinochloa colonum	Poaceae
Imperata cylindrica	Poaceae
Oplismenus compositus	Poaceae
Oryza sativa	Poaceae
Paspalidium flavidum	Poaceae
Paspalum conjugatum	Poaceae
Paspalum scrobiculatum	Poaceae
Phragmites karka	Poaceae
Polypogon fugax	Poaceae
Saccharum officinarum	Poaceae
Saccharum spontaneum	Poaceae
Setaria glauca	Poaceae
Vetiveria zizanioides	Poaceae
Carex myosurus	Cyperaceae
Cyperus bervifolius	Cyperaceae
Cyperus cyperoides	Cyperaceae
Fimbristylis dichotoma	Cyperaceae
Fimbristylis miliacea	Cyperaceae
Desmodium triflorum	Fabaceae
Medicago lupulina	Fabaceae
Melilotus indica	Fabaceae
Trifolium alexandrum	Fabaceae
Trifolium tomentosum	Fabaceae
Blainvillea acmella	Asteraceae
Parthenium hysterophorus	Asteraceae
Silybum marianum	Asteraceae
Xanthium strumarium	Asteraceae
Typha angustifolia	Typhaceae
Typha elephantina	Typhaceae
Hygrophila polysperma	Acanthaceae
Sagittaria sagittifolia	Alismataceae
Rorippa nasturtium aquaticum	Brassicaceae
Mosla dianthera	Lamiaceae
Nymphoides cristata	Nympheaceae
Oxalis corniculata	Oxalidaceae
Polygonum barbatum	Polygonaceae
Monochoria sp.	Pontederiaceae
Ranunculus scleratus	Ranunculaceae
Veronica anagalis aquatica	Scrophulariaceae

Only aerial parts, chiefly comprising leaves were fed. Root stock of *Typha* spp. was fed throughout monsoon while its fresh sprout was fed in winter and new leaves in summer.

5.3.2 Principal food

5.3.2.1 Grass

The principal food is defined as the percentage composition of the food items contributing maximum to the animal's diet. Those contributing below one percent are excluded. Nine species formed the principal grass food of swamp deer in Jhilmil (Table 5.3). The seasonal ranking of principal grass food for summer, monsoon and winter seasons are given in Table 5.4. Though, the composition of the species in the diet varied, there was not much variation in number of principal grass food in different seasons. *Imperata cylindrica* forms the major percentage of the diet throughout the year and different seasons. *Oryza sativa* which formed 8.04% of the overall diet figures in the ranking in monsoon only. *Cyrtococcum accrescens* (7.00% in overall), has first, fifth and no ranking in the winter, monsoon and summer seasons. In monsoon grass species contributed more than 50% to the diet compared to winter (46%) and summer (19%) seasons.

Table 5.3 Over all principal grass food of swamp deer in Jhilmil (irrespective of season)

Species	% in diet
Imperata cylindrica	11.31
Oryza sativa	8.04
Cyrtococcum accrescens	7.00
Saccharum officinarum	3.66
Paspalum conjugatum	1.99
Vetiveria zizanioides	1.67
Cynodon dactylon	1.54
Echinochloa colonum	1.44
Phragmites karka	1.31

Table 5.4 Seasonal principal grass food of swamp deer in Jhilmil

Season					
Winter		**Monsoon**		**Summer**	
Species	**% in diet**	**Species**	**% in diet**	**Species**	**% in diet**
Cyrtococcum accrescens	17.80	*Oryza sativa*	24.12	*Imperata cylindrica*	7.14
Imperata cylindrica	14.86	*Imperata cylindrica*	11.92	*Cynodon dactylon*	3.23
Paspalum conjugatum	4.95	*Saccharum officinarum*	8.18	*Phragmites karka*	2.07
Saccharum officinarum	2.79	*Echinochloa colona*	4.31	*Paspalidium flavidum*	1.84
Phragmites karka	1.86	*Cyrtococcum accrescens*	3.19	*Paspalum scrobiculatum*	1.84
Polypogon fugax	1.55	*Vetiveria zizanioides*	3.02	*Vetiveria zizanioides*	1.38
Cynodon dactylon	1.39	*Saccharum spontaneum*	2.01		

5.3.2.2 Herbs

Herb species contributed only 3.38% to the overall diet (Table 5.5) with 18.66% in summer and negligible contribution in winter and monsoon (Table 5.6).

Table 5.5 Over all principal herb food of swamp deer in Jhilmil (irrespective of season)

Species	% in diet
Oxalis corniculata	3.38

Table 5.6 Seasonal principal herb food of swamp deer in Jhilmil

Summer	
Species	**% in diet**
Oxalis corniculata	10.14
Mosla dianthera	2.76
Parthenium hysterophorus	1.38
Xanthium strumarium	1.38

5.3.2.3 Sedges

Sedge species contributed only 18.22% to the overall diet (Table 5.7) with 33.13% in winter, 11.17% in monsoon, and 10.37% in summer (Table 5.8).

Table 5.7 Over all principal sedge food of swamp deer in Jhilmil (irrespective of season)

Species	% in diet
Cyperus cyperoides	10.06
Fimbristylis dichotoma	4.43
Fimbristylis miliacea	2.34
Cyperus bervifolius	1.02

Table 5.8 Seasonal principal sedge food of swamp deer in Jhilmil

Season					
Winter		**Monsoon**		**Summer**	
Species	**% in diet**	**Species**	**% in diet**	**Species**	**% in diet**
Cyperus cyperoides	29.26	*Fimbristylis miliacea*	5.31	*Fimbristylis dichotoma*	8.99
Cyperus bervifolius	2.17	*Fimbristylis dichotoma*	4.31		
Fimbristylis miliacea	1.70				

5.3.2.4 Aquatic flora

Aquatic species contributed only 28.49% to the overall diet (Table 5.9) with 35.48% in summer, 30.79% in monsoon, and 19.20% in winter (Table 5.10).

Table 5.9 Over all principal aquatic species food of swamp deer in Jhilmil (irrespective of season)

Species	**% in diet**
Typha spp.	23.10
Veronica anagalis aquatica	1.49
Rorippa nasturtium aquaticum	0.67
Ranunculus scleratus	2.07

Table 5.10 Seasonal principal aquatic species food of swamp deer in Jhilmil

Season					
Winter		**Monsoon**		**Summer**	
Species	**% in diet**	**Species**	**% in diet**	**Species**	**% in diet**
Typha spp.	15.02	*Typha* spp.	30.79	*Typha* spp.	23.50
Veronica anagalis aquatica	2.17			*Ranunculus scleratus*	6.22
Rorippa nasturtium aquaticum	2.01			*Veronica anagalis aquatica*	2.30
	19.20			*Hygrophila polysperma*	1.38

5.3.3 Principal food in different habitats

The results of overall analysis for principal grass food species in different habitats are given in Table 5.11. Food species viz. *Imperata cylindrica*, *Cynodon dactylon*, *Oplismenus* sp., and *Oryza sativa* contributed most to the diet. Number of species contributing to much of the diet in agricultural land and scrub forest is three, in moist deciduous forest is two and in dry grassland is one.

Table 5.11 Principal grass food of swamp deer in different habitats

Species	% in diet	Species	% in diet
Agricultural field		**Scrub forest**	
Oryza sativa	21.96	*Imperata cylindrica*	28.17
Saccharum officinarum	18.77	*Paspalum conjugatum*	12.21
Polypogon fugax	9.43	*Vetiveria zizanioides*	11.36
Paspalum conjugatum	5.85	*Paspalum* sp.	9.09
Echinochloa colonum	3.40	*Saccharum spontaneum*	3.22
		Cynodon dactylon	2.35
Moist deciduous forest		*Phragmites karka*	1.61
Cynodon dactylon	30.77	*Setaria glauca*	1.15
Oplismenus spp.	23.08		
		Swamp	
Dry grassland		*Cyrtococcum accrescens*	11.64
Imperata cylindrica	53.29	*Phragmites karka*	7.11
Cynodon dactylon	10.29	*Coix lachryma-jobi*	1.07

In the case of herbs, the number of species contributing to the diet were comparatively few in all habitats (Table 5.12).

Table 5.12 Principal herb food of swamp deer in different habitats

Species	% in diet	Species	% in diet
Agricultural field		**Swamp**	
Trifolium tomentosum	5.47	*Oxalis corniculata*	3.97
Trifolium alexandrum	3.10	*Mosla dianthera*	1.25
Dry grassland		**Scrub forest**	
Desmodium triflorum	1.28	*Medicago lupulina*	3.03
		Silybum marianum	3.03
Moist deciduous forest			
Oxalis corniculata	46.15		

Number of sedge species forming the principal food was few in agricultural fields and scrub forest. They were absent altogether in moist deciduous forest and dry grassland (Table 5.13).

Table 5.13 Principal sedge food of swamp deer in different habitats

Species	% in diet	Species	% in diet
Agricultural field		**Swamp**	
Cyperus bervifolius	1.55	*Cyperus cyperoides*	14.05
		Carex myosurus	7.42
Scrub forest		*Fimbristylis dichotoma*	1.46
Cyperus cyperoides	8.56		
Cyperus bervifolius	7.87		

Number of aquatic species forming the principal food were fewest in all habitat types (Table 5.14).

Table 5.14 Principal aquatic species food of swamp deer in different habitats

Species	% in diet	Species	% in diet
Agricultural field		**Swamp**	
Veronica anagalis aquatica	13.46	*Typha* sp.	42.83
		Ranunculus scleratus	2.82
Dry grassland			
Hygrophila polysperma	1.80		

5.3.4 *Ivlev's electivity index*

During monsoons, all ten grass species (except *Paspalum conjugatum* and *Setaria glauca*) and *Typha* spp. were preferred whereas *Cyperus* spp. avoided (Fig 5.1).

In winters, in contrast to monsoon, *Paspalum conjugatum*, *Setaria glauca*, *Cyperus* spp. are preferred whereas *Typha* spp. avoided (Fig 5.2).

In summers, eight out of ten grass (*Paspalum conjugatum* excluded) and hydrophyte (*Typha* spp. included) species, all three sedge species and six out of nine herb species are preferred (Fig 5.3).

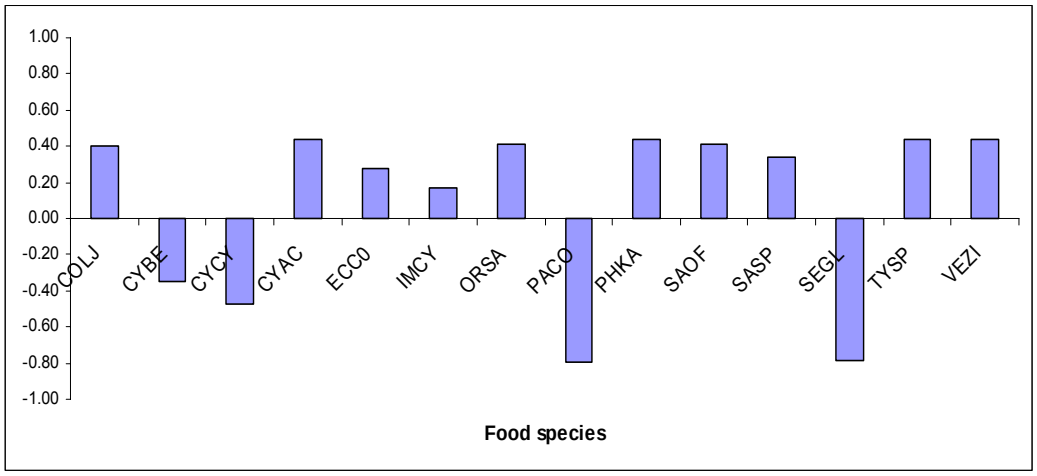


Fig. 5.1 Ivlev's index for food preference in monsoons

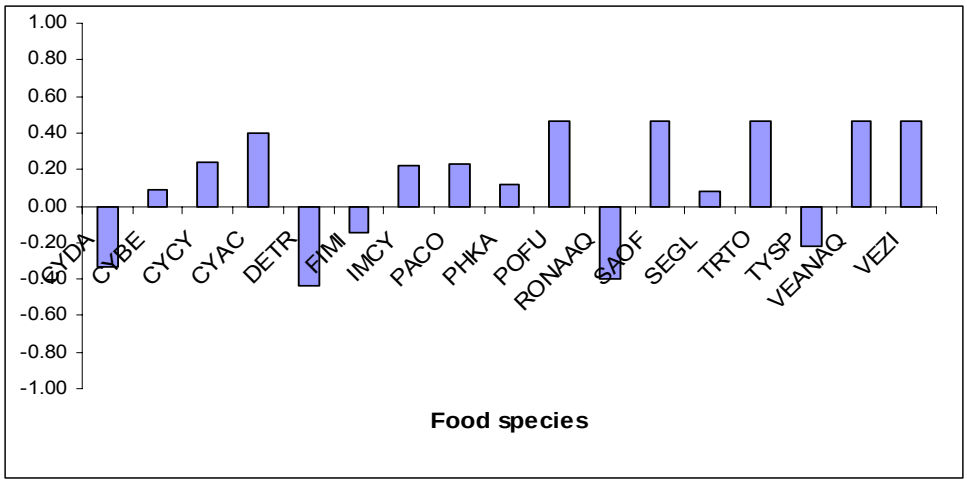


Fig. 5.2 Ivlev's index for food preference in winters

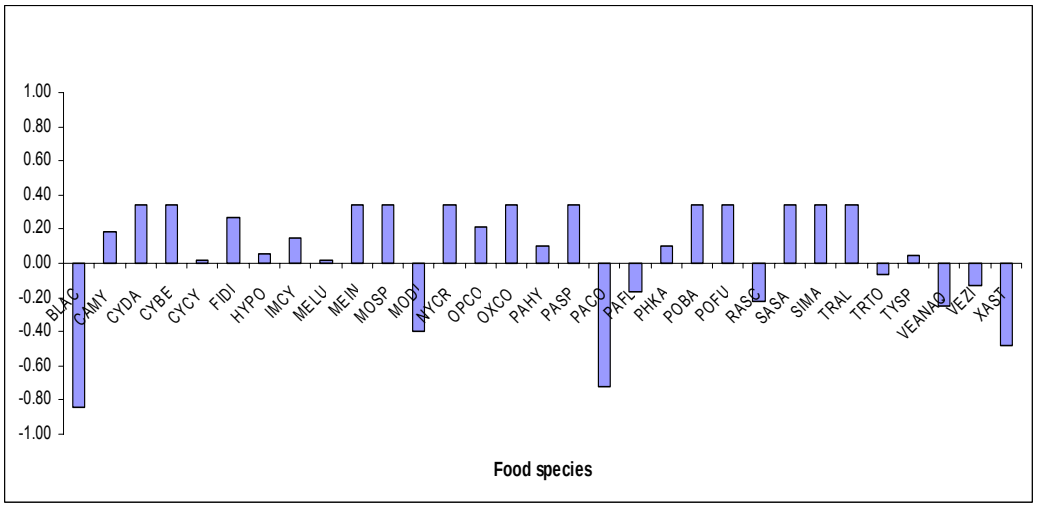


Fig. 5.3 Ivlev's index for food preference in summers

Blainvillea acmella	BLAC	*Melilotus indica*	MEIN	*Polypogon fugax*	POFU
Carex myosurus	CAMY	*Monochoria sp.*	MOSP	*Ranunculus scleratus*	RASC
Coix lacryma-jobi	COLJ	*Mosla dianthera*	MODI	*Rorippa nasturtium aquaticum*	RONAAQ
Cynodon dactylon	CYDA	*Nymphoides cristata*	NYCR	*Saccharum officinarum*	SAOF
Cyperus bervifolius	CYBE	*Oplismenus compositus*	OPCO	*Saccharum spontaneum*	SASP
Cyperus cyperoides	CYCY	*Oryza sativa*	ORSA	*Sagittaria sagittifolia*	SASA
Cyrtococcum accrescens	CYAC	*Oxalis corniculata*	OXCO	*Setaria glauca*	SEGL
Desmodium triflorum	DETR	*Parthenium hysterophorus*	PAHY	*Silybum marianum*	SIMA
Echinochloa colona	ECC0	*Paspalidium sp.*	PASP	*Trifolium alexandrum*	TRAL
Fimbristylis dichotoma	FIDI	*Paspalum conjugatum*	PACO	*Trifolium tomentosum*	TRTO
Fimbristylis miliacea	FIMI	*Paspalum conjugatum*	PACO	*Typha spp.*	TYSP
Hygrophila polysperma	HYPO	*Paspalum flavidium*	PAFL	*Veronica anagalis aquatica*	VEANAQ
Imperata cylindrica	IMCY	*Phragmites karka*	PHKA	*Vetiveria zizanioides*	VEZI
Medicago lupulina	MELU	*Polygonum barbatum*	POBA	*Xanthium strumarium*	XAST

5.3.5 *Marcum-Loftsgaarden analysis*

For monsoons the test statistics calculated is 90.79. The critical chi-square value with significance level 0.05 and 14 df is 23.69. For winters the test statistics calculated is 36.29. The critical chi-square value with significance level 0.05 and 17 df is 27.59. For summers the test statistics calculated is 14.43. The critical chi-square value with significance level 0.05 and 31 df is 44.99. The hypothesis of homogeneity is rejected only for monsoon and winter. This hypothesis is accepted for summer indicating that all species are utilized in proportion to their availability. Further, analogous confidence intervals for all $a_i - u_i$ of all categories in the two seasons are summarized in tables below.

Table 5.15: Marcum-Loftsgaarden analysis for monsoons

Species	No.of availabl plots	Proportion of available plots (a_i)	Expected no.of available plots	No.of utilize plots	Proportion of utilized plots	Expected no.of utilized plots	Confidence intervals		+ 0 -
							Lower bound	Upper bound	
Coix lachrym- jobi	5	0.01	6.92	4	0.03	2.08	-0.06	0.02	used in proportion
Cyperus bervifolius	6	0.01	6.92	3	0.02	2.08	-0.05	0.03	used in proportion
C.cyperoides	17	0.04	13.83	1	0.01	4.17	0.00	0.06	avoided
Cyrtococcum accrescens	6	0.01	9.22	6	0.05	2.78	-0.08	0.02	used in proportion
Echinochloa colonum	13	0.03	16.14	8	0.06	4.86	-0.09	0.03	used in proportion
Imperata cylindrica	23	0.05	23.83	8	0.06	7.17	-0.07	0.05	used in proportion
Oryza sativa	21	0.05	31.51	20	0.15	9.49	-0.19	-0.02	preferred
Paspalum conjugatum	19	0.04	15.37	1	0.01	4.63	0.00	0.07	avoided
Phragmites karka	8	0.02	12.30	8	0.06	3.70	-0.10	0.01	used in proportion
Saccharum officinarum	10	0.02	14.60	9	0.07	4.40	-0.11	0.01	used in proportion
S. spontaneum	5	0.01	6.15	3	0.02	1.85	-0.05	0.02	used in proportion
Setaria glauca	25	0.06	22.29	4	0.03	6.71	-0.02	0.08	used in proportion
Typha spp.	51	0.12	76.86	49	0.37	23.14	-0.37	-0.14	preferred
Vetiveria zizanioides	7	0.02	10.76	7	0.05	3.24	-0.09	0.02	used in proportion
Total	435			131					

Table 5.16: Marcum-Loftsgaarden analysis for winters

Species	No.of available plots	Proportion of available plots (a_i)	Expected no.of available plots	No.of utilized plots	Proportion of utilized plots	Expected no.of utilized plots	Confidence intervals		+ 0 -
							Lower bound	Upper bound	
Cynodon dactylon	7	0.02	7.36	3	0.02	2.64	-0.04	0.03	used in proportion
Cyperus bervifolius	6	0.02	5.89	2	0.02	2.11	-0.03	0.03	used in proportion
C.cyperoides	49	0.14	57.38	29	0.22	20.62	-0.19	0.02	used in proportion
Cyrtococcum accrescens	34	0.09	47.82	31	0.24	17.18	-0.25	-0.04	preferred
Desmodium triflorum	10	0.03	8.83	2	0.02	3.17	-0.02	0.05	avoided
Fimbristylis miliacea	8	0.02	8.09	3	0.02	2.91	-0.04	0.04	used in proportion
Imperata cylindrica	10	0.03	11.77	6	0.05	4.23	-0.07	0.03	used in proportion
Paspalum conjugatum	13	0.04	15.45	8	0.06	5.55	-0.09	0.03	used in proportion
Phragmites karka	4	0.01	4.41	2	0.02	1.59	-0.04	0.03	used in proportion
Polypogon fugax	5	0.01	7.36	5	0.04	2.64	-0.07	0.02	used in proportion
Rorippa nasturtium aquaticum	23	0.06	19.86	4	0.03	7.14	-0.02	0.08	avoided
Saccharum officinarum	3	0.01	4.41	3	0.02	1.59	-0.05	0.02	used in proportion
Setaria glauca	3	0.01	2.94	1	0.01	1.06	-0.02	0.02	used in proportion
Trifolium tomentosum	4	0.01	5.89	4	0.03	2.11	-0.06	0.02	used in proportion
Typha spp.	79	0.22	73.57	21	0.16	26.43	-0.04	0.16	used in proportion
Veronica anagalis aquatica	3	0.01	4.41	3	0.02	1.59	-0.05	0.02	used in proportion
Vetiveria zizanioides	2	0.01	2.94	2	0.02	1.06	-0.04	0.02	used in proportion
Total	263			129					

5.3.6 *Seasonal diet composition, based on faecal pellet analysis*

A lesser number of food plant species were identified by this method, when compared to the analysis of feeding signs. The reason was that monocot faecal fragments could not be differentiated to species level that's why named as similar species. While 13 plant species were identified from faecal fragments in summer, 8 were found for monsoon, and 12 for winter. The top five species in each season accounted for 80-92% of the diet (Table 5.17). Graminoids dominated the diet in summer (55.20%) and monsoon (75.86%).

The major species varied in the proportion of the diet that they constituted in most seasons. The presence of graminoids showed significant differences ($P<0.01$) between all seasons.

Seven species accounted for 78.6% of the overall diet. These included graminoids (60.88%, range: 51.58 to 83.10%), *Imperata cylindrica* (13.18%, range: 10.56 to 17.24%), *Fimbristylis* spp. (8.96%, range: 3.45 to 16.99%), *Cyrtococcum accrescens* (8.96%, range: 6.90 to 13.20%), *Saccharum* sp. (4.22%, range: 2.64 to 17.24%), *Paspalum* sp. (2.64%, range: 2.64 to 4.25%) and *Phragmites* sp. (2.42%, range: 2.29 to 4.25%).

In every season, a few species that were recorded from feeding signs, were not found in the faecal pellets. In summer, only 13 species were found in the faecal matter, whereas 28 species were recorded from feeding sites. In monsoon, 8 were recorded from pellets while 13 had feeding signs on them. In winter, 12 species were common to both methods. Of the top five species, all five were common to the two methods in the summer, monsoon and winter diets.

Table 5.17 Seasonal food plant species based on feeding signs (FS), and faecal pellet (FP) analysis

Species	Summer		Monsoon		Winter	
	FS	FP	FS	FP	FS	FP
Blainvillea acmella	*					
Carex myosurus	*	*				
Coix lachryma-jobi			*			
Cynodon dactylon	*	*			*	*
Cyperus sp.	*		*		*	*
Cyrtococcum accrescens			*	*	*	*
Desmodium sp.					*	
Echinochloa colona			*	*		
Fimbristylis sp.	*	*	*	*	*	*
Hygrophila sp.	*	*				
Imperata cylindrica	*	*	*	*	*	*
Medicago lupulina	*					
Melilotus indica	*					
Monochoria sp.	*					
Mosla dianthera	*	*				
Nymphoides cristata	*					
Oplismenus compositus	*					
Oryza sp.			*	*		
Oxalis corniculata	*	*				
Parthenium hysterophorus	*					
Paspalidium sp.	*					
Paspalum sp.	*	*	*		*	*
Phragmites karka	*	*	*		*	*
Polygonum barbatum	*					
Polypogon sp.	*				*	*
Ranunculus scleratus	*	*				
Rorippa nasturtium aquaticum					*	*
Saccharum sp.			*	*	*	*
Sagittaria trifolia	*					
Setaria sp.			*		*	
Silybum marianum	*					
Trifolium sp.	*				*	
Typha spp.	*	*	*	*	*	*
Veronica anagalis aquatica	*	*			*	*
Vetiveria zizanioides	*	*	*	*	*	
Xanthium strumarium	*					

5.3.7 *Food availability*

Analysis of variance (ANOVA) indicated that season and habitat had significant effect on food availability of only grasses while only total food availability varied significantly with season. Habitat alone had significant effect only on herb food availability. Two way interactions between season and habitat in only total food and grasses turned out to be significant (Table 5.18-5.22).

Table 5.18 Influence of habitat and season on total food availability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.356(a)	13	1.027	19.875	.000
Intercept	49.153	1	49.153	950.868	.000
Season	9.102	2	4.551	88.038	.000
Habitat	.275	4	.069	1.329	.258
Season x Habitat	2.508	7	.358	6.931	.000
Error	20.987	406	.052		
Total	**81.957**	**420**			
Corrected Total	**34.344**	**419**			

a. R Squared = .389 (Adjusted R Squared = .369)
b. Computed using alpha = 0.05

Table 5.19 Influence of habitat and season on grass food availability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.638(a)	13	.511	8.194	.000
Intercept	24.578	1	24.578	394.398	.000
Season	3.439	2	1.720	27.596	.000
Habitat	1.502	4	.375	6.024	.000
Season x Habitat	1.172	7	.167	2.688	.011
Error	16.452	264	.062		
Total	**68.977**	**278**			
Corrected Total	**23.090**	**277**			

a. R Squared = .287 (Adjusted R Squared = .252)

Table 5.20 Influence of habitat and season on sedge food availability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.044(a)	5	.009	1.372	.247
Intercept	.953	1	.953	148.623	.000
Season	.006	2	.003	.430	.652
Habitat	.020	2	.010	1.532	.224
Season x Habitat	7.46E-005	1	7.46E-005	.012	.914
Error	.398	62	.006		
Total	**1.648**	**68**			
Corrected Total	**.442**	**67**			

a R Squared = .100 (Adjusted R Squared = .027)

Table 5.21 Influence of habitat and season on herb food availability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.077(a)	6	.013	4.682	.001
Intercept	.209	1	.209	75.824	.000
Season	.003	1	.003	.997	.323
Habitat	.049	3	.016	5.931	.002
Season x Habitat	.012	2	.006	2.148	.128
Error	.127	46	.003		
Total	**.819**	**53**			
Corrected Total	**.204**	**52**			

a R Squared = .379 (Adjusted R Squared = .298)

Table 5.22 Influence of habitat and season on aquatic flora food availability

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.318(a)	6	.053	2.799	.017
Intercept	.571	1	.571	30.121	.000
Season	.068	2	.034	1.790	.175
Habitat	.070	2	.035	1.835	.167
Season * Habitat	.063	2	.032	1.668	.196
Error	1.327	70	.019		
Total	**4.049**	**77**			
Corrected Total	**1.645**	**76**			

a R Squared = .194 (Adjusted R Squared = .124)

The results of biomass estimation for food species are summarized in Tables 5.23. Scrub forest had almost uniform availability of total food species in monsoon and winter season while dry grassland, swamp, and moist deciduous forest were uniform in winter and summer. Agricultural fields showed a rapid decline in food availability from monsoon to summer.

Agricultural fields and moist deciduous forest varied in grass food throughout the season while scrub forest, dry grassland, and swamp had almost uniform grass availability in winter and summer. Dry grassland had uniform sedge availability in monsoon and winter while swamp had in monsoon and summer. Dry grassland had uniform herb availability in winter and summer while other habitats do not.

Aquatic plant availability varied considerably across seasons and habitats without a definite trend.

Table 5.23 Habitat-wise food availability in different seasons (gram dry biomass/m^2)

Habitat		Season		
	Food type	Monsoon	Winter	Summer
Agricultural fields	Total	19.4	8.94	3.65
	Grass	19.4	7.59	0.26
	Sedge	0	0	1.25
	Herb	0	0.74	1.54
	Aquatic plants	0	0.29	0.86
Scrub forest	Total	13.36	13.92	5.38
	Grass	13.36	1.70	3.17
	Sedge	0	0	0
	Herb	0	0.4	2.08
	Aquatic plants	0	0	0
Dry grasslands	Total	16.77	7.20	8.86
	Grass	14.69	6.56	4.18
	Sedge	2.08	2.02	0
	Herb	0	0.1	0.1
	Aquatic plants	0	0.06	2.35
Swamp	Total	20.05	6.50	6.46
	Grass	13.07	2.95	1.44
	Sedge	0.67	2.66	0.38
	Herb	0	0	0.77
	Aquatic plants	6.31	2.19	1.54
Moist deciduous forest	Total	0	6.33	4.61
	Grass	0	15.65	8.95
	Sedge	0	0	0
	Herb	0	0	0
	Aquatic plants	0	0	0

5.4 Discussion

The herbivore diet is influenced by several factors including anatomical and physiological characteristics of the animal, community structure of the plants, and its structural and chemical constituents (Owen-Smith, 1982). Food intake of animals is also influenced by body weight which sets limit to the gut size and the digestibility (Baile, 1975; Bines, 1976). In the protected areas studied earlier the swamp deer habitat was dominated by grasses and hence they were reported to be almost exclusive grazers by Schaller (1967) and others. In contrast, at Jhilmil the area also has equal presence of other plant types viz. sedges, herbs and aquatic species. This resulted in polyphagous feeding habit of animal here.

Plants of the family Poaceae together with Cyperaceae form the major food of swamp deer in Jhilmil. Tropical grasses have a C4 photosynthetic pathway characterized by a specialized leaf anatomy, higher growth rate and nitrogen use efficiency (Norton, 1982). They are also capable of accumulating starch and reserve polysaccharides which are easily digestible.

The study on habitat use of swamp deer in Jhilmil indicates the preference of grasses throughout the year (chapter 4). However, principal and preferred food of swamp deer in Jhilmil varied in number as well as in the rank order of its preference index according to seasons and habitat types. Seasonal and habitat related variation in food preferences have also been reported in swamp deer by Martin (1977), Singh (1984), Qureshi et al (1995) and in white-tailed deer by Padmalal et al (2004). The habitat type, plant species availability, and season are the major factors operating on the preference of a species (Crawley, 1983). But the feeding strategy is also based on minimizing the concentration of toxins while maximizing nutritive value.

The proximate factor influencing the decision on consumption of a plant is the palatability. The present study also shows that swamp deer is a grazer depending mostly on grass species throughout the year. However, the proportion of terrestrial and aquatic herbs in diet increased gradually in winter and summer seasons. Grasses of tropics have been reported to show an increased content of structural constituents with maturity which reduces digestibility (Reid and Jung 1965; Gomide et al. 1969) and the proportion of stem also increases with maturity (Jones and Wilson 1987).

Plants take up minerals rapidly during early growth and the content of most minerals fall with advancing maturity as dry matter accumulates more rapidly than minerals in matured plants especially due to decrease in leaf percentage where minerals are considerably higher (Jones and Wilson 1987). Lyttleton (1973) has reported low protein content at mature stages in dry season due to water stress. Evidences of reduced nitrogen content in plant at high temperature have also been made (Colman and Lazenby 1970). The

higher proportion of matured grasses in the environment during dry season explains switching over to other food species.

Mixed feeders, depending on the grass and aquatic flora in their diet commonly concentrated on grasses during high rainfall periods and high rate of grass growth. Their switching to other foods during dry periods increase (*pers. obs*.).

Frequency distribution of different feeding habits between different age and sex categories and between seasons within categories did not showed significant difference. Yearling and fawn categories did show difference between seasons in feeding habits but that does not reflect the actual situation. It might probably be because of low sampling intensity (fewer sightings).

The overall diet, based on results from both methods, consisted mainly of herbs (terrestrial and aquatic) and graminoids. The proportion of graminoids in the diet decreased in winter and summer and consumption of herbaceous flora (primarily aquatic) increased. Swamp deer showed shifts in their diet to specific part (root stock) of *Typha* spp. in monsoon for physiological requirement. This is presumed to be a way to supplement calcium intake (Boyd 1969). In summer, there is an equal choice both for new leaves of *Typha* spp. as well as sedges. This can be attributed to their almost equal availability and palatability. In this study site the overall principal diet of swamp deer constitutes of *Typha* spp. in contrast to *Imperata cylindrica* reported by all the authors in past. The reason is *Typha*'s availability and proportion area covered in comparison to *Imperata* grasslands.

Faeces collected in winter showed presence of *Zizyphus mauritiana*, *Diplocyclos palmatus*, and *Desmodium* sp. seeds. *Zizyphus mauritiana* has been reported been eaten by swamp deer in Dudhwa by Singh (1984) and Qureshi et al (1995) but was never recorded by me during direct observation because it was not visible from the observation posts. *Diplocyclos palmatus* was interestingly never encountered during vegetation sampling. Though

feeding signs were recorded on *Desmodium* sp. in winter but it was not found in faecal fragments.

Thus the diet of swamp deer at Jhilmil Jheel Conservation Reserve which is mainly made up of leaves of graminoids and herbaceous flora is occasionally supplemented by fruits also. In all tropical ungulates, it is strongly influenced by the phenology and availability of vegetation. In winter, they are generalist feeders, being able to adapt to changes in phenology and availability of vegetation. They are selective only in monsoon, the time of abundant food supply, and are non-selective or opportunistic feeders in summer when food is limiting.

Chapter 6

Activity pattern and time budget

CHAPTER 6
ACTIVITY PATTERN AND TIME BUDGET

6.1 Introduction

Information on activity pattern of a species helps in understanding the energetics and survival strategies in their habitat. This information is particularly important in understanding their foraging behaviour. The energetic costs of various activities can provide daily, seasonal, and annual energy expenditure estimates for each species within that particular habitat. Activity pattern and time budget are expected to differ according to the age and sex of the animal. Abiotic factors are also considered to have greater influence on these.

In this context the present study becomes more important because the study area Jhilmil Jheel, a Conservation Reserve is in the midst of human settlement and forms the natural habitat of swamp deer. The daily activity cycle of the animal would therefore be much influenced by the existing human activities and increases the relevance of the study. It is hypothesized that the diurnal activity pattern of the swamp deer would differ from those of protected areas.

Further, activity pattern and time budget are expected to differ according to the sex of the animal. So, the present study focuses on diurnal activity pattern and time budget of male and female swamp deer and its seasonal variations.

Objectives

- To record diurnal activity pattern of swamp deer
- To determine the variation in activity between the sexes
- To determine the seasonal variation in activity pattern

6.2 Methodology

Field methods

Data were collected from June 2006 to June 2008 and were divided into six, four-month period corresponding to summer, monsoon, and winter. Monitoring was done from the vantage points/ observation post (Buckland 1973). Swamp deer were observed with the aid of 15x45 spotting scopes and 8x40 binoculars. Each season was divided into 10 sessions of 12 days each. In each session 5 hours fore- noon and 5 hours after noon sampling was done. Thus a total of 100 hours of observation per season have been compared. The diurnal cycle was divided into five periods: (1) 0700-0900 (2) 0900-1100 (3) 1100-1300 (4) 1300-1500 (5) 1500-1700 hours. The time periods in winters were different from monsoons and summers because of poor visibility (fog). Hence the activity graphs give a fraction of the 10 hour rhythms of the individuals recorded on different days in a season. These periods were selected because activity of swamp deer reportedly was greatest at dawn and dusk (Schaller 1967).

The data on activity pattern and time budget were collected through instantaneous scan sampling (Altmann 1974). An activity was defined as any activity for which the time spent in that activity exceeded 30 seconds before changing to the next activity. Since the animals were observed in groups, observation was taken once in 15 minutes. Thus four samples were taken in an hour.

Activities of the animals were classified as follows

1. Feeding: Feeding on different food species both during walking and standing.
2. Walking: Walking at a steady pace or movements from one location to another without feeding a minimum standard distance?
3. Running was included in moving only
4. Lying/ ruminating/ basking used as resting
5. Social activities: grooming, chasing, rutting (sparring), scanning, standing, wallowing, drinking water

For each observation taken the vegetation type in 10 m radius around the animal was also recorded.

Analysis

Time investment by swamp deer in various activities during theses diurnal periods is analyzed for both the sex categories. It is proportional mean of each activity for each time period. The samples for each activity were averaged on two hourly basis and its standard error estimated. The number of samples ranged from a minimum of one to a maximum of one hundred sixty.

The numbers of scans are converted into hours by considering 4 scans/ hour. Percentage means of all the activities in five time periods and different vegetation types in different seasons, both on male and female during the two year study period are summarized in Table 4.1-4.6.

Comparatively more scans are for both male and female during summers. This could be attributed to the visibility because of reduced vegetation cover.

The seasonal activity pattern is analyzed using contingency table test to find whether the time spent in a particular activity varies over seasons. The comparisons were considered to be significantly different upto $p \leq 0.05$ level.

Total time spent in different vegetation types is also calculated as proportional means of each.

6.3 Results

Activity Budget

During monsoons, the animals fed intermittently throughout the day without any conspicuous morning and evening peaks of feeding activity. As a general trend feeding is followed by walking. Resting was observed during morning hours (0700-1100) in case of males only.

Males spent about 40% time each in feeding and ruminating in winter. Fig. 6.3 indicates time spent on social activities viz., sparring which is not seen in females.

During summer, most of the individuals spent 3.5% of their time in walking between 0700 to 0900 hours and 1500 to 1700 hours. It was reduced

to nil during the noon hours. Number of individuals feeding and lying, gradually increased during the noon hours. These reached a peak during late noon hours; where after maximum animals were feeding only. Swamp deer was never seen drinking during morning hours. This activity was observed only during noon hours. Drinking normally occurred after intensive feeding, while walking to canopy cover for lying or at the time of walking to feeding sites. Social behaviour viz., grooming and ear waving was mostly during the lying period after the intensive feeding but also occurred in the early morning hours. Time is also spent in wallowing by males (table 6.1-6.2, figure 6.1-6.6).

Table 6.1 Percentage time spent by males during different time intervals in various activities

	Time intervals	Walking	Feeding	Lying/Ruminating	Social activities
Monsoon	0700-0900 (n=12)	50±0.15	33±0.14	17±0.11	0
	0900-1100 (n=11)	27±0.14	55±0.16	18±0.12	0
	1100-1300 (n=12)	8±0.08	92±0.08	0	0
	1300-1500 (n=7)	0	100	0	0
	1500-1700 (n=9)	11±0.11	89±0.11	0	0
Winter	0830-1030 (n=41)	3±0.03	31±0.07	55±0.07	11±0.04
	1030-1230 (n=73)	3±0.02	42±0.05	38±0.05	18±0.04
	1230-1430 (n=65)	3±0.02	36±0.06	41±0.06	15±0.04
	1430-1630 (n=70)	11±0.04	38±0.06	39±0.06	12±0.04
Summer	0700-0900 (n=123)	6±0.02	43±0.04	39±0.04	12±0.02
	0900-1100 (n=111)	5±0.01	43±0.04	39±0.04	13±0.03
	1100-1300 (n=137)	0	59±0.04	35±0.04	6±0.02
	1300-1500 (n=126)	0	53±0.04	46±0.04	1±0.01
	1500-1700 (n=156)	4±0.01	60±0.03	30±0.03	6±0.02

(Figures in parenthesis are total number of scans)

Table 6.2 Percentage time spent by females during different time intervals in various activities

	Time intervals	Walking	Feeding	Lying/ Ruminating	Social activities
Monsoon	0700-0900 (n=1)	0	1		
	0900-1100 (n=3)	30±0.3	70±0.3		
	1100-1300 (n=2)	0	1		
	1300-1500 (n=1)	0	1		
	1500-1700 (n=5)	20±0.2	80±0.2		
Winter	0830-1030 (n=16)	5±0.05	16±0.09	73±0.11	6±0.06
	1030-1230 (n=32)	9±0.05	56±0.09	28±0.08	6±0.04
	1230-1430 (n=30)	17±0.07	51±0.09	29±0.08	3±0.03
	1430-1630 (n=43)	15±0.05	39±0.07	46±0.07	0
Summer	0700-0900 (n=131)	2±0.01	17±0.03	23±0.04	5±0.02
	0900-1100 (n=117)	1±0.01	17±0.03	28±0.04	2±0.01
	1100-1300 (n=146)	0	35±0.04	26±0.03	4±0.01
	1300-1500 (n=132)	0	28±0.03	32±0.04	1±0.01
	1500-1700 (n=160)	2±0.01	24±0.03	26±0.03	5±0.01

(Figures in parenthesis are total number of scans)

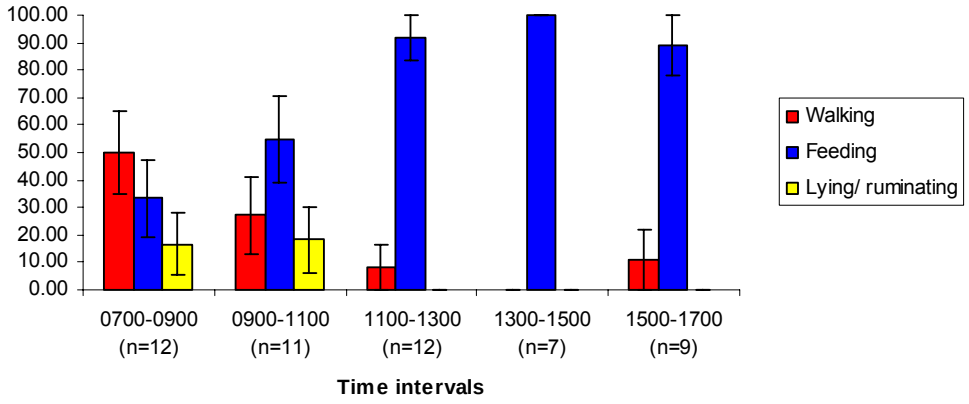


Fig.6.1 Percentage time spent by male during different time intervals in various activities during monsoons

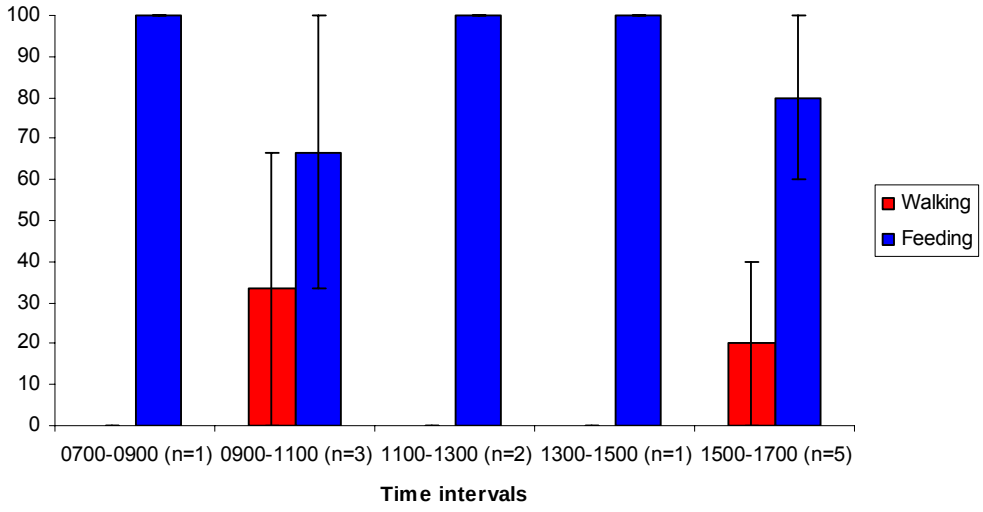


Fig.6.2 Percentage time spent by female during different time intervals in various activities during monsoons

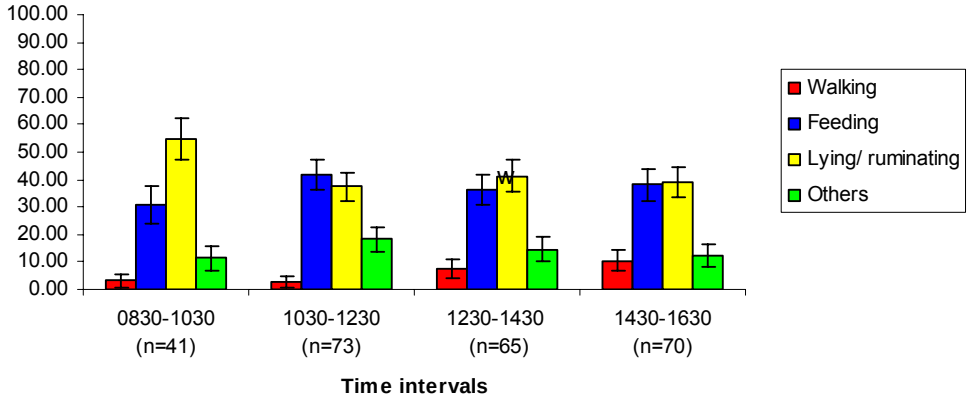


Fig.6.3 Percentage time spent by male during different time intervals in various activities during winters

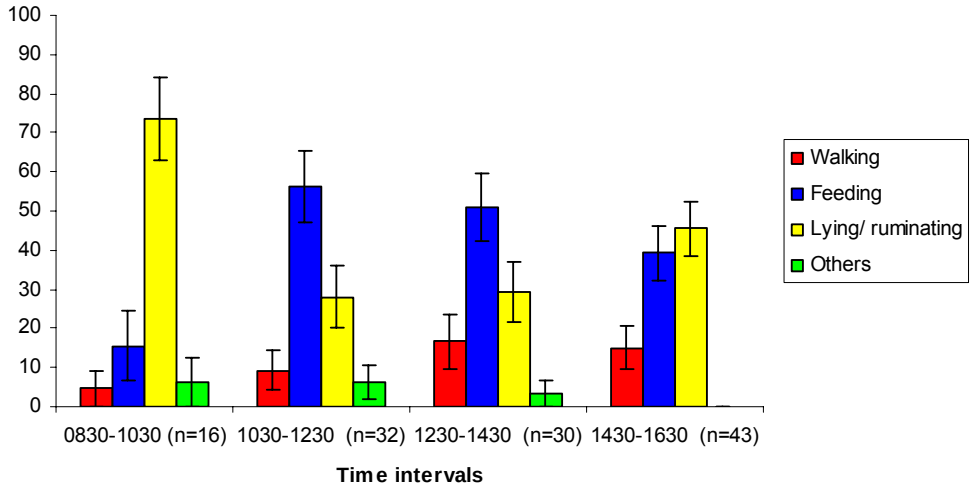


Fig.6.4 Percentage time spent by female during different time intervals in various activities during winters

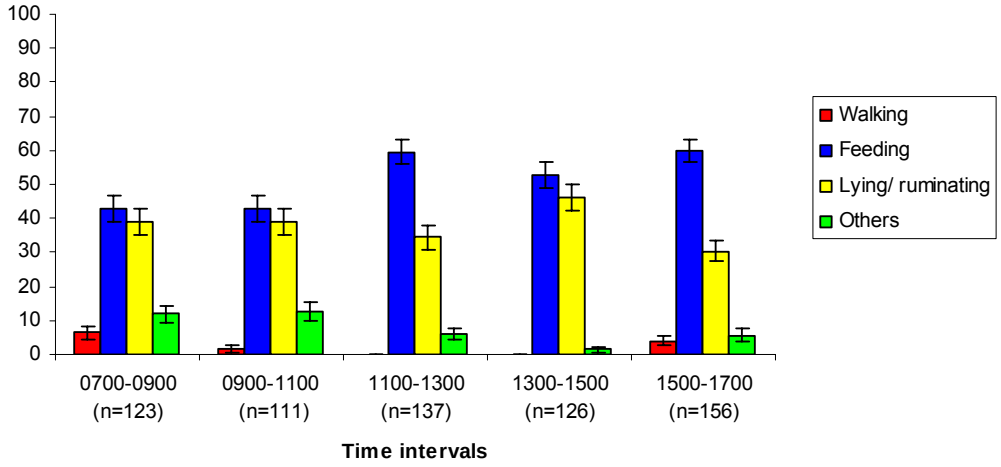


Fig.6.5 Percentage time spent by male during different time intervals in various activities during summers

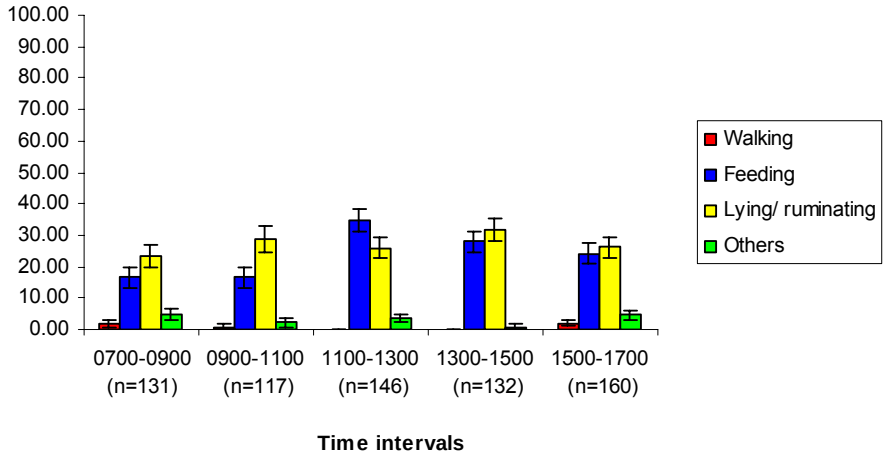


Fig.6.6 Percentage time spent by female during different time intervals in various activities during summers

6.3.2 Seasonal differences in the diurnal activity pattern

Males

The activity-time budget of the males during three seasons is shown in figure 6.7. Maximum walking was observed during monsoon and summer between 7-9 hours, while it was between 13-15 hour during winter. Average time spent in walking was highest in monsoon, followed by winter and least in summer. There were no significant differences in time spent in walking between seasons (χ^2=0, *df*=8, *p*=1).

During monsoon bouts of feeding were noticed throughout the day with peaks at 1300-1500 hours. In winter the feeding peak shifted to 900-1100 hours. A bimodal pattern in feeding was seen during summer between 1100-1300 hour and 1500-1700 hour. Average time spent in feeding was highest during monsoon, followed by summer and least in winter. The time spent in feeding varies significantly between seasons (χ^2=2.98, *df*=8, *p*=0.9356).

A bimodal lying/ ruminating pattern was seen during monsoon between 0700-1100 hours while maximum time was spent lying between 0700-0900 hours in winter. In summers the peak shifted to 1300-1500 hours. Average time spent in lying/ ruminating is highest in winter, followed by summer and least in monsoon. There were no significant differences in time spent in lying/ ruminating between seasons (χ^2=0.26, *df*=8, *p*=1).

No social activity was prominent during monsoons. The peak of 'social activities' chiefly sparring was observed between 0900-1100 hours in winters. In summers 'social activities' mainly included standing and scanning, which was highest between 0700-1100 hours. Average time spent in 'social activities' is higher in winter and lower in summer. There were no significant differences in time spent in 'social activities' between seasons (χ^2=0, *df*=8, *p*=1).

Females

The percentage time spent by females in the various activities from 0700-1700 hrs during the three seasons is shown in figure 6.8. The peaks of walking in monsoon are between 0900-1100 and 1500-1700 hours, while in winter between 1100-1300 hours. In summer, walking again showed a bimodal pattern with peaks between 0700-0900 hours and 1500-1700 hours. Average time spent in walking was equal in monsoon and winter but reduced it in summer.

Feeding showed a polymodal pattern with peaks occurring at 0700-0900, 1100-1300 and 1300-1500 hours during monsoon. In winter the peak was observed between 0900-1100 hours and in summer between 1100-1300 hours. Average time spent in feeding is highest in monsoon, followed by summer and least in winter.

Females spent maximum time in resting between 0700-0900 hours during winter. During summers resting time shifted to 1300-1500 hours. Average time spent in lying/ ruminating was higher in summer, as compared to winter.

Social interactions were not noticed during monsoons. In winter, two peaks of social activities viz., rutting were clear between 0700-1100 hours. During summers they were between 0700-0900 and 1500-1700 hours. Average time spent in 'social activities' is higher in summer, as compared to winter.

Only time spent in feeding varied significantly between seasons (χ^2=4, *df*=8, *p*=0.9381), while time spent in resting, moving and social interactions did not (table 6.3).

Table 6.3 Average percentage of time spent by males and females in the activity categories

Percentage time										
	Male					Female				
Season	Monsoon	Winter	Summer	χ^2	p	Monsoon	Winter	Summer	χ^2	p
Walking	19	6	2	0	1	11	11	2	0	1
Feeding	74	37	52	2.98	0.9356	89	40	44	4	0.9381
Lying	7	43	38	0.26	1	0	44	49	0	1
Social activities	0	14	8	0	1	0	4	6	0	1

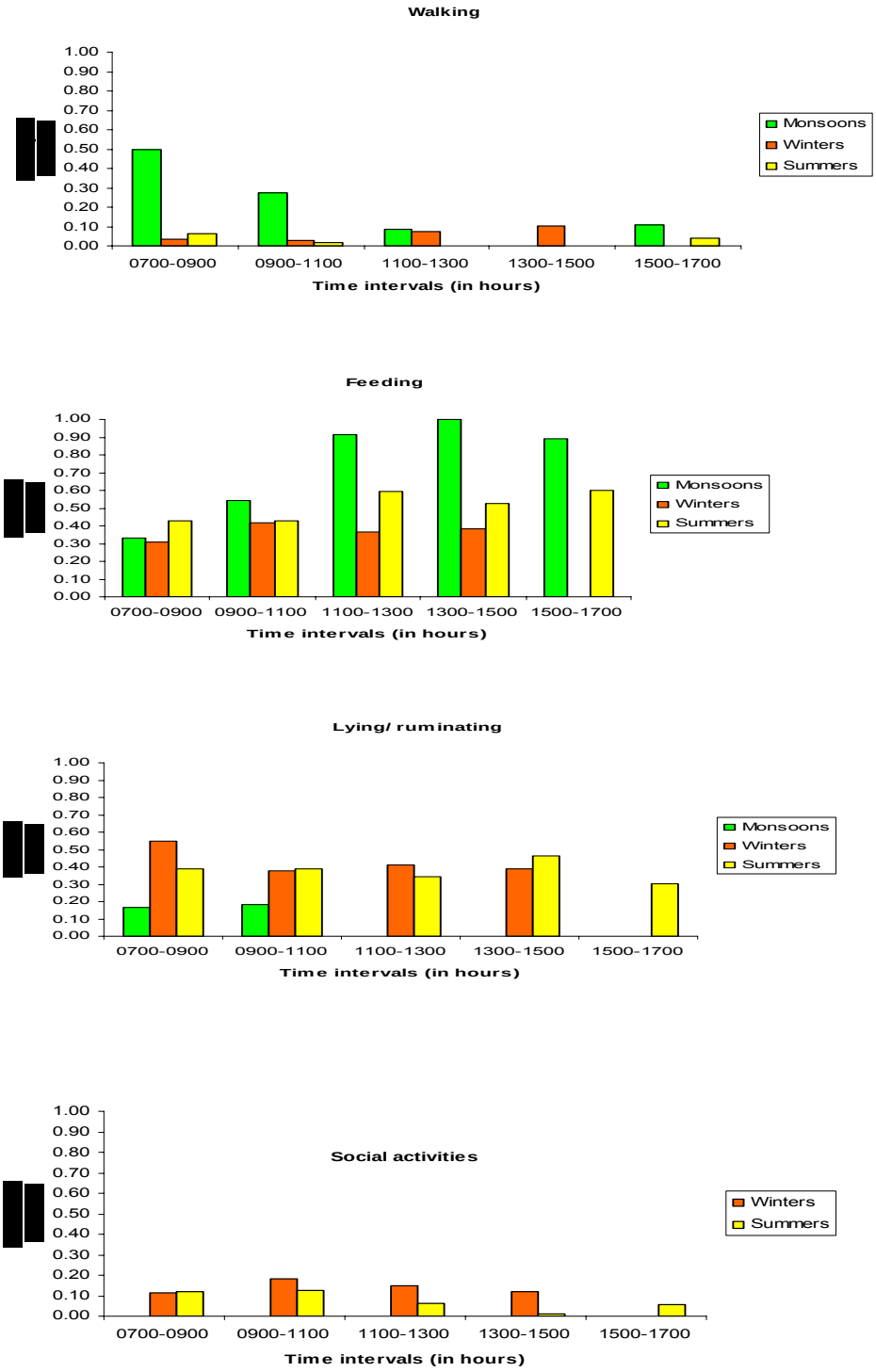
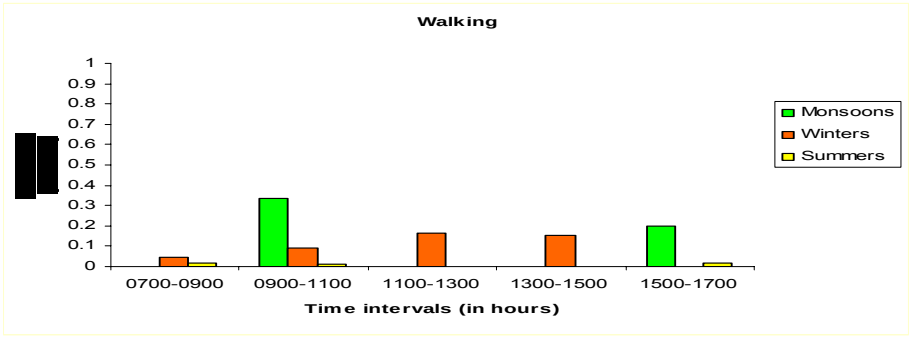
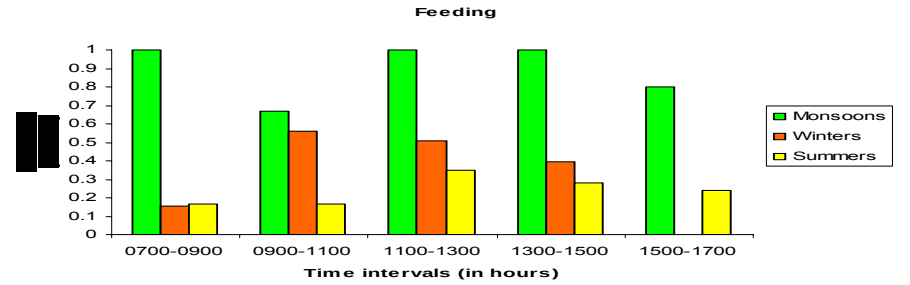
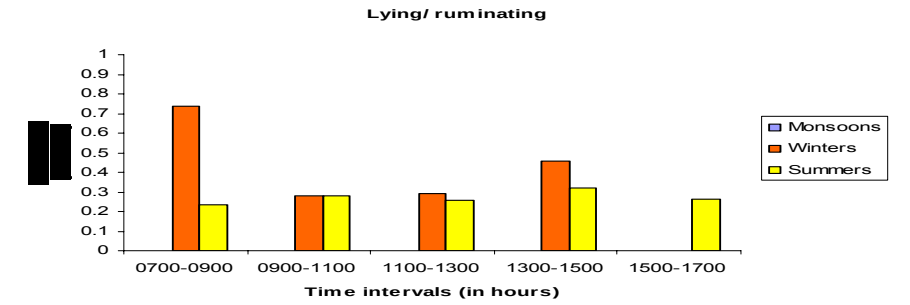


Fig 6.7 Seasonal differences in the diurnal activity pattern by males







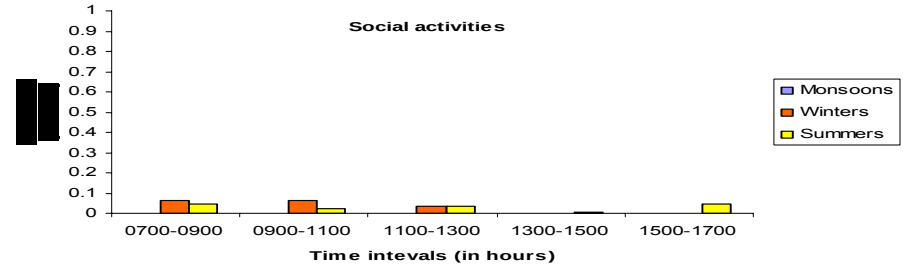


Fig.6.8 Seasonal differences in the diurnal activity pattern by females

6.3.3 Comparison of activity patterns in different vegetation types

The observation hours were from dawn to dusk. It was the time when the human movement was at peak in crop fields (for various agricultural activities), scrub forest and dry grasslands (for cattle grazing) and moist deciduous forest (for collection of fuelwood etc.). That is why animals were never located in these habitat types during the day time and they cannot be considered for analysis.

Monsoon

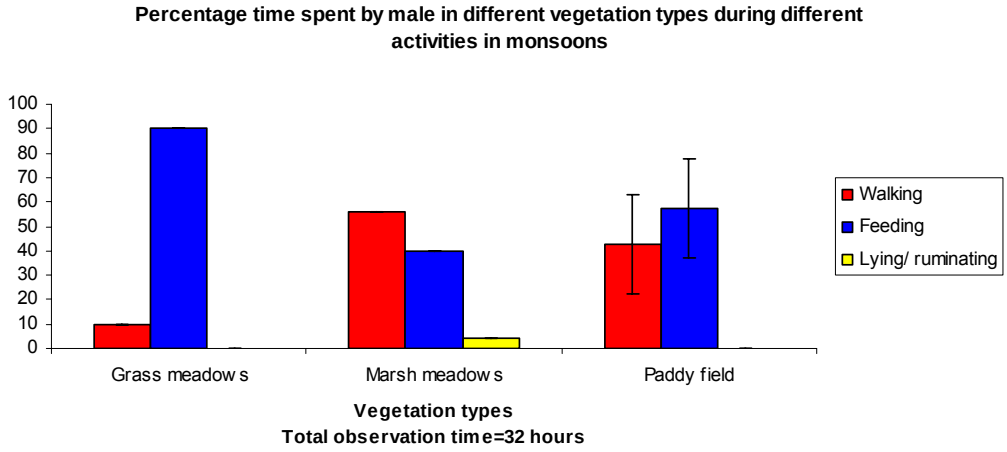
In grass meadows both sexes spent most of the time in feeding. In paddy fields males spent more time in feeding than walking as opposed to females. In marsh meadows, both sexes fed, walked, and rested.

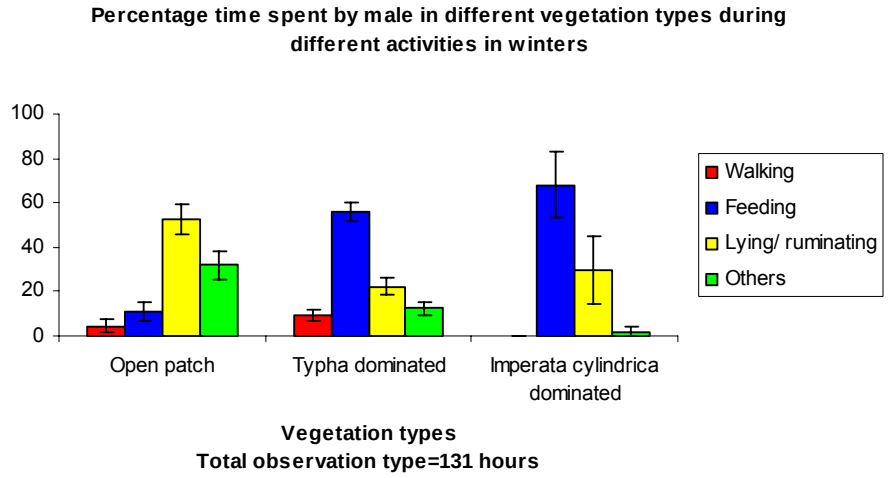
Winter

Males in open patch spent the most time in resting, followed by sparring, feeding, and walking. In open patches females spent more time in lying, feeding, vigilance and walking in descending order. In marsh meadows, animals, fed, rested, sparred and walked in the same order.

Summer

In sedge meadow, grass meadow and open patch both sexes spent most of their time in resting, followed by feeding and social interactions. Marsh meadows were used by both sexes only for feeding (Figure 6.9-6.10).





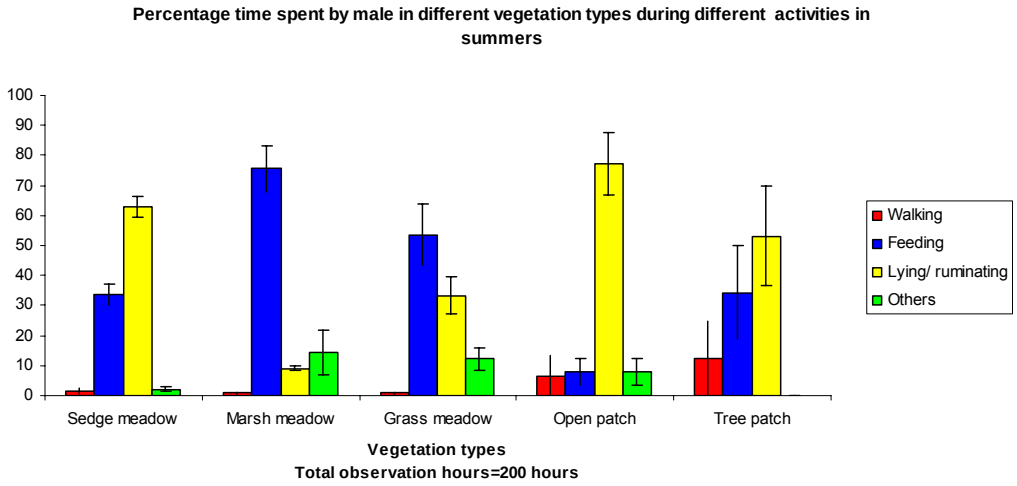
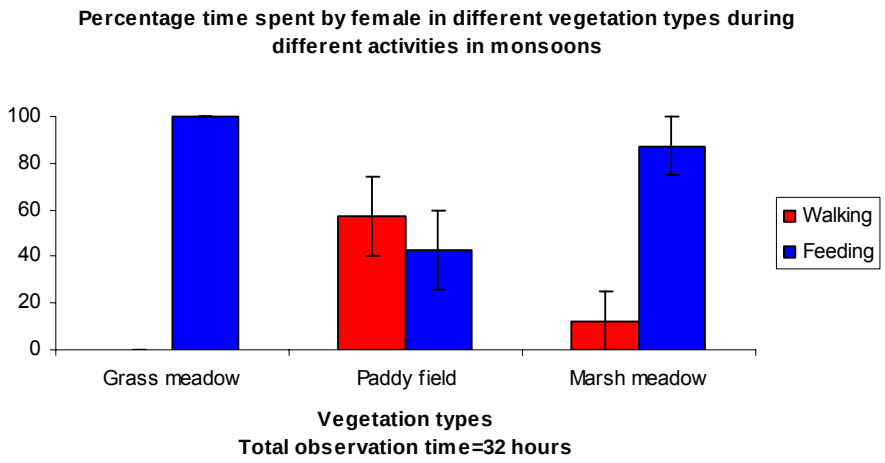


Fig 6.9 Comparison of activity patterns in different vegetation types by males



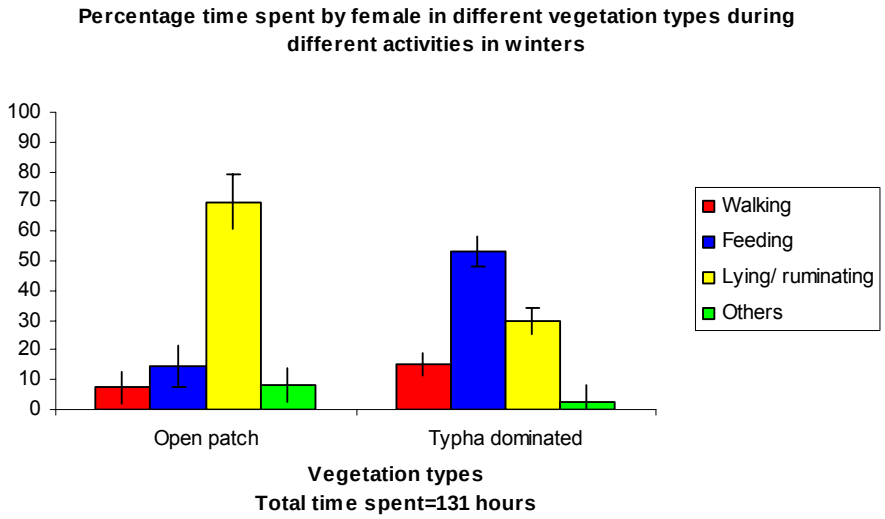


Fig 6.10 Activity patterns in different vegetation types by females

6.4 Discussion

The body of any organism requires a variety of activities associated with procurement of food, shelter, and protection. Each of these activities have certain benefit and costs attached to it (Sharatchandra and Gadgil 1980). An obvious principle is that the extent of activity must be adequate to maintain the

kind of life permitted by the animal's anatomic and physiological adaptations (Davis and Golley 1963).

Time budget mediate relation between the environment, individual requirement and the resulting sociality (Caraco 1979a). Temperature and food availability are important environmental factors influencing activity pattern and time budget. Through the analysis of time budget for basic activities, the following explanation emerges of how the swamp deer maintain themselves in different seasons.

6.4.1 Activity Budget

Monsoons

Monsoon is the time for the antler growth (Prater 1971). Since food plays an important role in antler growth, males are found feeding round the day. Walking time is inverse to feeding. Resting is found only during morning hours because they go active as sun rises high. Feeding by females most of the times can be explained both by abundance of food (chapter 5) and their physiological needs. Food (mainly grasses) provides most of the nutrient required for the developing embryo or for nursing the young (Prater 1971). Females spend time in walking only to approach various vegetation types or to pools or streams for drinking water. Sitting was not observed in females as for considerable period they were found nursing the young ones in thick vegetation cover and detailed activities under thick vegetation could not be recorded.

Winters

Overall time spent on feeding and lying/ruminating was almost equal because at any point of time some herds were feeding while others were lying/chewing cud. Feeding was always followed by walking. Sparring occurred frequently as winter forms the rutting period of the species and the stags fight for the possession of the hinds (Prater 1971).

Time spent in feeding and ruminating in case of females also equal for the same reasons. Time is spent on walking in search of food, as forage biomass goes low (30%). Very less time (3.5%) was spent in social activities as they are they are on the receiving end during rut and are not involved much.

The females spent a significantly more time in vigilance than the males. The possible reason for this could be, the females in general are more cautious and watchful, both while feeding and while at rest, than the males. This may be because the females were seen in groups and could easily be spotted and would probably need to doubly ensure whether there would be any sort of danger before they resort to bedding.

Summer

The patterns of walking and feeding of males explain each other. The noon hours were spent in feeding only (usually standing) and walking only took place between the bouts. Lying was at peak during late noon hours 1300-1500 hours) as it formed the hottest period of the day. The animals were observed to lie in the cover, and rumination mostly occurred during this posture. Time was spent in wallowing due to soaring temperatures which forces the animals to do so.

The reason that more time was spent in resting by females as compared to males was that the adult females have conceived by end of winters, so adult member herds are found lying round the day. Time is spent in social activities like drinking water and ear waving while standing.

6.4.2 Seasonal differences in the diurnal activity pattern

During monsoon and summer at 0700-0900 hours of light most of the individuals spent time in feeding areas (35%) and in between move considerably between different patches of vegetation.. During winter, most individuals spent most of time in basking in the afternoon and move at 1300-1500 hours from one feeding ground to other in search of already sparse forage. Walking always corresponds to feeding, therefore average walking time

drops from monsoon to winter as average feeding time also is lesser in winter than monsoon.

During monsoon peak almost all the individuals are involved only in feeding at 1300-1500 hours when all. In winter maximum individuals get into feeding at 0900-1100 hours while in summer most individuals go active twice in a day i.e., at 1100-1300 and 1500-1700 hours. Average feeding time is highest in monsoon on account of forage abundance. In summer season availability of grass was lower and of low quality. Selection of less fibrous food, switching to browse, or increase ruminating are the options of a ruminant in an environment with low quality food (Beekman and Prins 1989). Partitioning their time budget for feeding and ruminating would be ideal during hot climatic conditions. Further, the general tendency of the animal will be to reduce the foraging costs and conserve body energy (Gates and Hudson 1979). Since lying is closely related to ruminating, the winter season decrease in feeding and increase in lying by swamp deer in the study area could be considered as the strategy to conserve energy by reducing forage costs.

In winter maximum of the individuals are found resting in morning hours, while in summer at 1300-1500 hours. In case of males, lying time is maximum in winter, followed by summer. On the other hand for females lying time is higher in summer as the adult members conceive, and are lying most of the time. In monsoon all the time is utilized for feeding by both the sexes.

Winter is the rutting season for swamp deer and hence some or the other pair of adult males spent considerable time in sparring round the day with maximum of them involved during 0900-1100 hours, which makes it peak for ‘social activities’ in winter. In summer, on the other hand animals are alert and scanning more during the early hours as the human activities are more during this phase only and else they slow down in the later part of the day. In case of males, winter involves more time in ‘social activities’ on account of rutting behaviour whereas in summer it constitutes only of minor activities like standing, scanning, drinking water etc. on contrast in females, ‘social activities’ are less in winter and more in summer.

6.4.3 Comparison of activity patterns in different vegetation types

Monsoon

As majority of time (80%) during monsoons is spend in feeding and *Cyrtococcum accrescens*, *Phragmites karka* and *Typha elephantina* forms the most of the food cover, males spend their time either in marsh meadows or grass meadows. Someday a herd was also seen feeding in paddy. Marsh meadows were also visited for drinking water as it had the major stream of the swamp. The observation of drinking water with head lowered, however, was missed because of dense vegetation cover. Some small herd was also found ruminating in thick *Typha* cover accounting for such low value of average time spent in cud chewing.

Winter

During winter season males spend their comparatively more time in open or in cleared patches to get enough sun, while sparring also takes in these patches. The animals clear these patches by laying down the long leaves of *Typha*, making it sort of a bed for lying down.

Unlike males females are found sometimes in herds with males or isolated in open as well as in thickets of *Typha* spp.

Summer

During summers, since food availability is low, so the animals are found visiting a variety of vegetation types. Some herds were seen in sun in sedge meadows, some in open patch next to a big stream while others in tall grasses of *Phragmites* and *Typha* (which probably acts as thermal cover for them). Some herds were found feeding/basking/standing in grass meadows while others under the shade of *Salix* trees. Pools with aquatic vegetation like are visited only for feeding. Similar activity patters are found with females but they are mostly in isolated herds. This is the reason they are not found lying in under the shade of *Salix* trees.

6.4.4 General

Majority of wild ungulates are with many phases of daily activity rhythm in which feeding bouts are interspersed with social activities. The present study in Jhilmil Jheel indicate that the daily activity pattern of swamp deer is of polyphase where feeding is interspersed with lying and walking. Feeding itself showed a polymodal pattern with peaks found in different time periods. Swamp deer in Jhilmil Jheel Conservation Reserve did not exhibit strong bimodal peaks in activity at dawn and dusk as shown in previous studies inside fully protected areas (Schaller 1967, Martin 1977 and Khan et al 2004). Though these bimodal peaks are based on human related factors only (Seshadri 1969) but as mentioned above, these factors are stronger at Jhilmil. A village (Tatwala) is in close proximity. So the swamp deer get into peak of activities before dawn and after dusk.

Chapter 7

Population Structure

CHAPTER 7
POPULATION STRUCTURE

7.1 Introduction

No work has been done on estimation of population structure of swamp deer in their, this distribution range. The Barasingha group size shows marked seasonal changes in response to breeding and food availability. The smallest groups (5-15) were formed during winter, followed by monsoon (10-25) and summer (10-50) (Martin 1977, Schaff 1978, Singh 1984, Sankaran 1989, Qureshi et al. 1995). The single individuals were observed largely during rutting season (winter and late monsoon) and large groups (mean 32, range 2-250) were found more common during summer, which is largely a congregations in response to new flush in burnt flood plain grasslands (Schaff 1978, Qureshi et al. 1995). The all male group is largely seen during summer and late winter, while mixed groups are seen through out the year with highest proportion in summer. Barasingha is monoestrous and monotochus in nature, females reproduce at the age of 2 to 3 years and males of age greater than 4 years contribute to breeding (Schaller 1967, Martin 1977, Schaff 1978, Qureshi et al. 1995). The gestation period in barasingha is 240 to 250 days (Asdell 1964). The sex ratio in all three sub species ranged from 40 to 80 stags per 100 hinds (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Sankaran 1989, Qureshi et al. 1995). Barasingha female including the two year aged female observed to have reproductive rate of 20 to 45 fawns per 100 hinds (Schaller 1967, Martin 1977, Schaff 1978, Singh 1984, Sankaran 1989, Qureshi et al.1995).

Data on population structure is vital for conservation and management of a species. In absence of baseline data on population structure for the species, no suitable management strategy can be evolved by wildlife managers. In case of Jhilmil Jheel, swamp deer are the flagship species. Moreover, the habitat in Jhilmil Jheel Conservation Reserve is facing threat of ever increasing anthropogenic pressure, particularly livestock grazing. Swamp deer may be affected due to fluctuating habitat conditions. The population

structure variables are therefore most suitable tools to assess impact of habitat changes on swamp deer populations. Goodman et al., 2001 studied effect oh habitat fragment size on effective population size of sika deer (*Cervus nippon*). This chapter provides the results of population monitoring done in Jhilmil Jheel Conservation Reserve.

Objectives

- To study variation in group composition in different vegetation types, among different seasons and in two years.
- To study change in mean group size with change in season and year.

7.2 Methodology

Data collection

Data on population structure was collected through direct observations in Jhilmil Jheel Conservation Reserve. Data collection was done during monsoon season of 2006 and 2007, winters of 2006 and 2007, and summer seasons of 2007 and 2008.

Since swamp deer change their positions with seasons in search of grazing cover, hiding cover or thermal cover; observation posts were also changed with seasons. Monitoring from these posts was carried out from 0600-1800 hours. For each sighting of swamp deer, following data were recorded

a) Vegetation/ habitat type
b) Distance from water body
c) Proximity to domestic livestock
d) Group composition and number of individuals, age-sex category

Individuals in the group were classified into different age and sex classes based on the criteria mentioned below following Martin (1977) with appropriate modifications.

1. Adult male:- 5 and above brow tines on backside pair of antlers
2. Sub adult male:- 2-3 brow tines on backside pair of antlers

3. Yearling male:- Carry spikes of 7-20 cm length
4. Adult female:- Very bulky and shaggy abdomen
5. Sub adult female:- two third the size of adult female
6. Yearling female:- half the size of sub adult female
7. Fawn:- Male have antlers in the form of small bumps while both sexes are mostly accompanied by mother

Data analysis

The sightings of swamp deer in different habitat/ vegetation types were summarized for each season. The one way ANOVA will be used to test the significant differences in the group composition and mean group size in different vegetation types and in different seasons between different years. All statistical tests are done using computer program SPSS. Sex ratio was taken as number of males in proportion to 100 females.

7.3 Results

7.3.1 Group size

The overall mean group size of swamp deer in all the three seasons was 10$\pm$0.47. Where as, the mean group size was observed highest in summer 13$\pm$0.75 and lowest in monsoons 3$\pm$0.25 (Table 7.1). The mean group size of swamp deer varied significantly across different seasons ($F=34.780$, $df=2$, $p<0.05$, One way ANOVA).

7.3.2 Age and sex ratio

In winter, stags and hinds were found in 36:100 ratio in open patch but mixed herds (1: 1) were found in marsh meadows. Fawn to female ratio was 1: 1 both in open and marsh meadows. The male: female and fawn: female ratios did not varied significantly across different sites ($F=0.850$, $df=1$, $p>0.05$) and ($F=0.294$, $df=1$, $p>0.05$) respectively.

In summer, male herd was seen feeding in marsh meadows and bachelor herds were resting in tree patch. All other vegetation types witnessed mixed herds. 2 out of 10 females were accompanied by fawns. The

male: female ratio varied significantly across different sites ($F=11.460$, $df=5$, $p<0.05$) but fawn: female ratio did not varied significantly ($F=2.249$, $df=5$, $p>0.05$).

In monsoon, paddy field witnessed male: female in 1: 1 ratio and marsh meadows had 17: 100 ratio. On an average, 4 out of 10 females were seen with fawns. The male: female and fawn: female ratios varied significantly across different sites ($F=6.016$, $df=1$, $p<0.05$) and ($F=52.364$, $df=1$, $p<0.05$) respectively.

Overall 100 females had 122 males and 34 fawns. Highest number of males (145) was found in summers and lowest in monsoons (55). Maximum number of fawns was evident in winter (59) and lowest in summers (18) (Table 7.2). The male: female and fawn: female ratios varied significantly across different seasons ($F=3.734$, $df=2$, $p<0.05$) and ($F=10.340$, $df=2$, $p<0.05$) respectively.

Table 7.1 Mean group size of swamp deer among different seasons

	Group size				
Season	**N**	**Mean**	**±S.E.**	**Minimum**	**Maximum**
Monsoon	83	3	0.25	1	11
Summer	688	13	0.75	1	104
Winter	371	6	0.24	1	38
Overall	381	10	0.47	1	51

Table 7.2 Number of males (AM) and fawns (FN) per 100 females in different seasons

	Winter			Summer			Monsoon		
Vegetation types	**N**	**AM**	**FN**	**N**	**AM**	**FN**	**N**	**AM**	**FN**
Grass meadows				14	145	16			
Open patch	11	36	73	3	78	0			
Marsh meadows	40	50	29	34	190	16	3	9	0
Sedge meadows				51	233	6			
Paddy field							5	100	80
Total	90	93	59	150	145	18	11	55	36

7.4 Discussions

Deer were generally assumed to have reached firm group sociality. This idea apparently originated from the descriptions given by Darling (1937) for red deer in Scotland. More recent studies however revealed that grouping

is largely dependant upon environment and changes in physiological functions.

Largest herds were found in summer similar to reports of previous authors (Martin, Schaff, Singh, Sankaran, Qureshi et al). In contrast to observations of authors in past, smallest herds were reported in monsoon instead of winter, the reason being poor sighting on account of dense vegetation cover. Other observations (like bachelor herds, mixed herds, and single individuals seen in various parts of the year) were similar to those of earlier authors.

In winters, the fawn to female ratio was maximum, as fawning was over by this time and fawns were big enough to follow mother.

Highest male to female ratio was observed in summer when deer congregate. In monsoon fawning affect the group structure. Single female in advanced pregnancy tend to separate from herd.

Schaller (1967) stated that barasingha groups tend to break up and reassemble in different groups. It was observed during this study also, that barasingha groups occasionally changed their composition several ties a day. Individuals of a group often scattered while grazing, which incidentally led to the breakup of the group. Single animals or small parties later met with different animals on grazing grounds or shady resting locations to form again larger groups.

Frequent changes of group composition were particularly conspicuous during the dry season. This was the period, when the daily movement pattern was lively and strongly influenced by the availability of food, water, and shade.

The frequent changes in group size and composition and the adaptation to different vegetation types lead to the conclusion that barasingha groups have no real constancy in the social sense. Even breeding groups were subject to constant exchange of individuals.

The highest degree of stability in this respect was noted during monsoon when food was abundant and daily movements at minimum. Congregation in one group, however, appeared to be accidental and caused by coincident grazing ground, rather than by social factors. The only stable relationship between two animals seemed to occur between a hind and her fawn, until the latter was approximately 1 year old.

According to this, grouping in barasingha is most probably a function of environment, except perhaps for the deviation in grouping habits that was found during the rutting period.

Chapter 8

Habitat conservation evaluation and threat assessment for Swamp Deer

CHAPTER 8
HABITAT CONSERVATION EVALUATION AND THREAT ASSESSMENT FOR SWAMP DEER

8.1 Introduction

At the time of rediscovery of swamp deer around Jhilmil Jheel in the year 2005 itself, it was realized that the habitat was too small in comparison to the need of swamp deer and other large herbivores (Qureshi et al. 1995). The composite home range of herds range from 10 to 30 km^2, annually (Qureshi et al. 1995). Barasingha on an average move 2-3 km (straight line) daily and known to move distances of 5-7 km during seasonal shifts of habitat (Martin 1977, Schaff 1978, Singh 1984, Sankaran 1989, Qureshi et al. 1995). Whereas, the area available to the swamp deer is 2.886 km^2. So a need was felt to assess the conservation reserve area as well as adjoining areas for identification of similar habitat blocks. Once these habitat blocks are demarcated, the next step will be to suggest the means of establishing linkage of the presently available habitat with neighbouring Terai habitat for future conservation in perpetuity.

The grasslands and woodland of Jhilmil Jheel Conservation Reserve also have large cattle and human populations dependent on resources of these patches in terms of fodder, fuelwood, and timber requirements (Plate 8.5). High dependency of local people on resources of these natural tracts poses severe threats to ungulate community and their long term conservation. Swamp deer is surviving here in an island habitat surrounded by various land use/ land cover types. It is an ‘exacting’ species and needs its traditional and wintering feeding grounds to be restored to it. These most essential cover requirements of its crucial phase of life cycle are at risk in the existing situation. If we intend to conserve this threatened species in its western most range, improvement of the status of vegetation and habitat conditions of this region is required. In order to evolve a suitable conservation strategy for swamp deer population, it is

imperative that the current threats to this species and the habitats it utilizes (Plate 8.6-8.7) are assessed.

This chapter therefore addresses the following objectives of the study:

1. Evaluate the suitability of the intensive study area and adjacent habitat blocks as swamp deer habitat
2. Suggest ways to provide linkage between available habitat and potential habitat blocks
3. Identification as well as quantitative assessment of major threats to swamp deer population and its habitats in Jhilmil Jheel Conservation Reserve and adjoining areas

8.2 Methodology

Critical habitat parameters for swamp deer, viz., forage, rutting/ breeding grounds, thermal and hiding cover (see chapter 4) and availability of water bodies were quantified to assess the availability and suitability of the habitat.

Data on various threat parameters was collected during the general survey of extent of the area carried out in different seasons using a variety of sampling techniques (see chapter4). A questionnaire survey was conducted among villagers and gujjar community settled around Conservation Reserve area and data on (i) number of families (ii) total number of residents (iii) number of livestock with each family and (iv) percentage land area under cultivation will be collected. In each habitat type, 10m radius circular plots will be established randomly to assess the human presence, cattle grazing incidences, feral dog presence, lopping, and tree cutting. Number of cattle dung piles and garbage were counted within the sampling plot. All these were then converted on ordinal scale.

Data analysis

Density of trees and shrubs per hectare was computed in all vegetation types. Percentage cover of ground vegetation was also computed. Case processing summary was then applied using SPSS program to get a mean value of different layers for each habitat type. Bray-Curtis cluster analysis using 'Bio Diversity Professional' software was done to test the similarity in species composition among utilized and potential habitats.

All threat variables assessed in and around prime swamp deer habitat were converted on ordinal scale 1 to 4 where 1 represented low threat and 4 represented highest value of a threat parameter. For each site, number of cut trees, lopped and cattle dung piles were added together to calculate mean values for these parameters. These mean values were ranked on ordinal scale of 1 to 4 for each site. Ordinal scores for different threat parameter at different sites were added together to calculate a mean threat score for each habitat type.

Delineation of water bodies

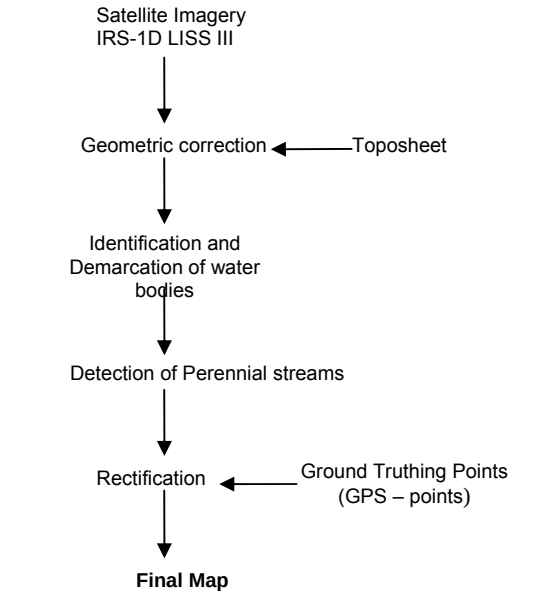


Fig. 8.1 Flowchart summarizing the method employed for delineation of the water bodies

The proportion of perennial and seasonal water bodies in Conservation Reserve were analysed using Survey of India Toposheet (1:50,000; 53K/1) overlaid with remote sensing data. One scene of LISS III (IRS-1D satellite of 15 May 2003 was procured from National Data Centre, National Remote Sensing Agency, Hyderabad. The satellite data had spatial resolution of 23.6 m and comprises four spectral bands (Figure 8.2).The classification of land cover / water bodies and other categories was done following an unsupervised ISODATA classification techniques using ERDAS IMAGINE 8.7 software. Visual interpretation was carried out for the delineation of water bodies. Habitation, agriculture, canals and roads were also identified. The

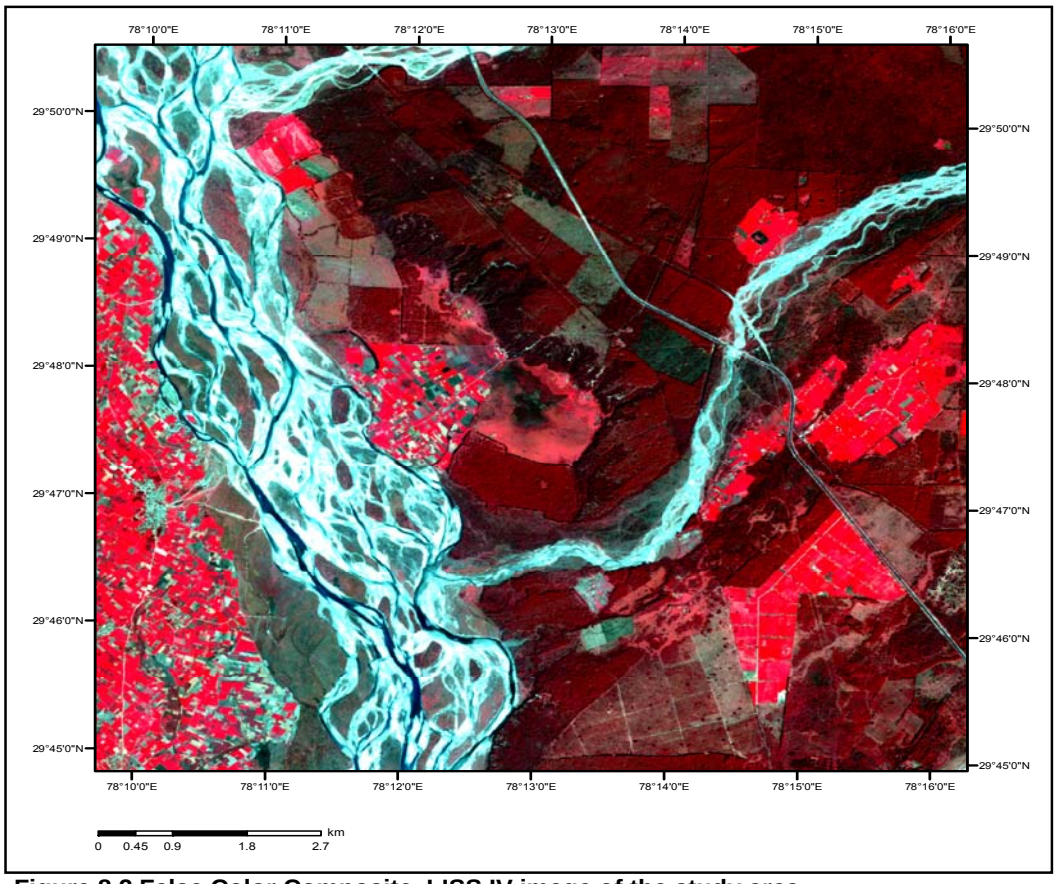


Figure 8.2 False Color Composite, LISS IV image of the study area

identified categories were verified in the field (ground truth verification). Rivers and perennial streams along with Jhilmil wetland were digitized from the satellite imagery using Arc GIS 9.2. In the attribute table, area was calculated through geo spatial analysis for the respective polygons (Lillesand and Kiefer, 2000).

Why connectivity?

It is presumed that increasing the connectivity between the isolated patches may counteract the adverse effects of fragmentation on swamp deer. Individually, Jhilmil Jheel, “the swamp” is not large enough (0.486 sq km in area) to support self sustaining populations for long, they may be dependent on adjoining patches.

There are some habitat blocks in the reserve area itself (viz. riverine forest, plantations and sandy river bed) which have been reported (riverine forest-Martin 1977, plantations-Qureshi et al. 1995, sandy river bed-Schaller 1967) as being used by swamp deer during various phases of their life cycle (Plate 8.1-8.3). These parts of the reserve cannot be used by the animal due to fragmentation (Figure 8.3).

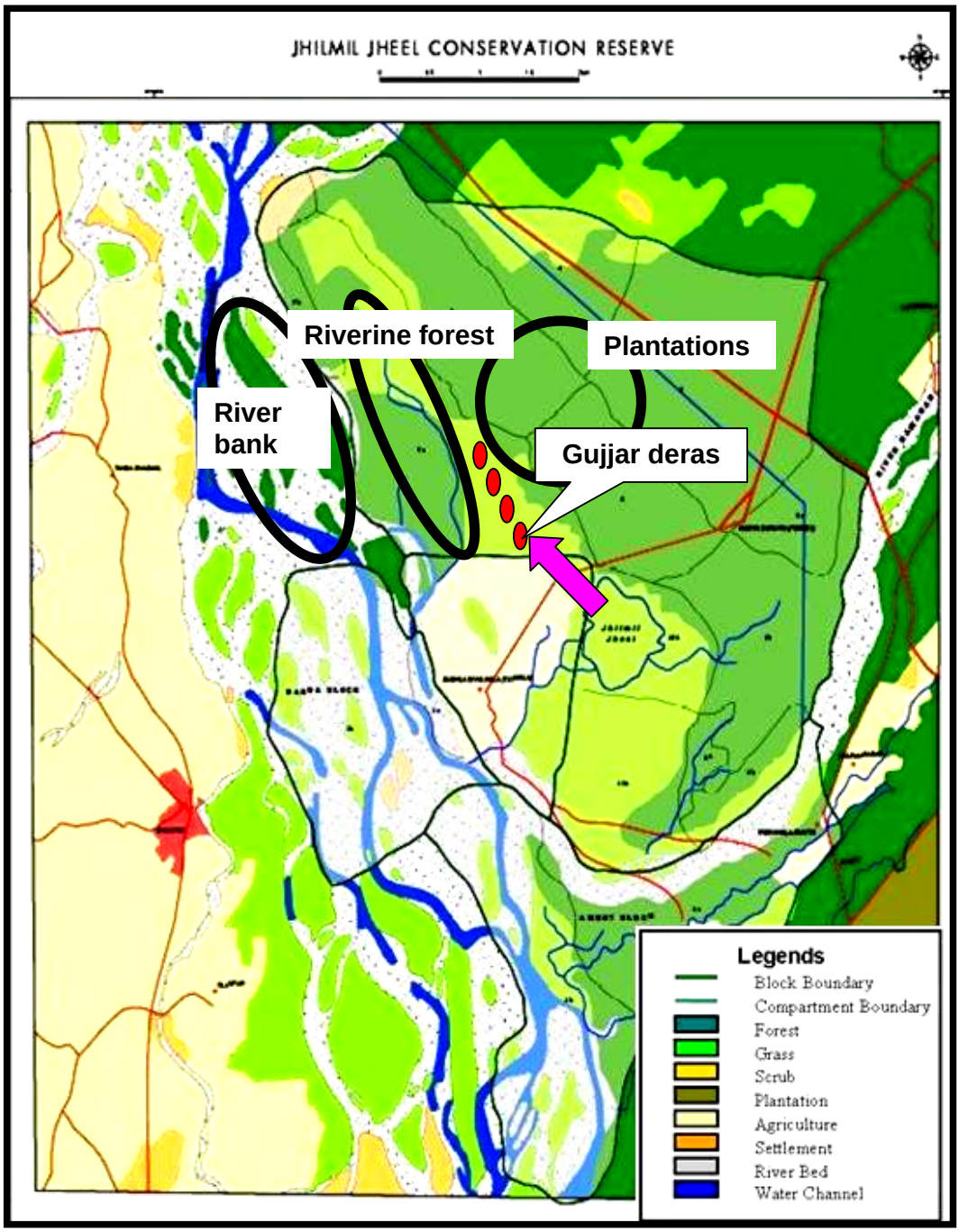


Figure 8.3 Map of JJCR showing potential habitat blocks

8.3 Results

(i) Total area under water bodies is 3.8625 sq km which forms 10.21% of the study area.

(ii) A total of 347 plant species were collected and identified. The identified species belonged to 89 families. A list of plant species identified during the surveys in given in Appendix-I.

(iii) A total 57 species of plants were recorded in this habitat type of which there were four species of trees, thirty six species of herbs, eleven species of grasses four species of climbers and two species of sedges.

(iv) A total 29 species of plants were recorded in this habitat type of which there were six species of trees, two species of shrubs, thirteen species of herbs, six species of grasses and two species of pteridophytes.

(v) In dry grassland, one species of pteridophyte, one species of sedge, four species of grasses and three species of herbs were recorded.

(vi) Swamp is characterized by high density of grass and hydrophyte species and low occurrence of shrubs. A total of 26 species of hydrophytes, 24 species of herbs, 17 species of sedges, 7 species of grasses, 4 species of trees, and only two species of shrubs were recorded in this vegetation type.

(vii) The characteristics of a miscellaneous moist deciduous forest are high tree and shrub density with sparse ground cover. A total of 135 species were recorded from this habitat type out of which 59 were

tree species, 17 were shrub species, 44 were herb species, 13 were grass species, and 2 were pteridophytes.

(viii) One tree species *Oroxylum indicum*, on sedge *Cyperus niveus*, one herb species *Centella asiatica* and one climber *Tinospora cordiflolia* was found only in riverine forest.

(ix) Of the entire Conservation Reserve area swamp cover 1 %, dry grassland 2 %, scrub forest 1 %, moist deciduous forest 2% and plantations 94 %. The tree and shrub density along with cover percentage of individual layers in each habitat type among different seasons is given in Tables 8.1-8.3.

Test for variation in composition of key habitat variables between utilized and potential habitat types in summer and monsoon

Bray-Curtis cluster analysis also shows resemblance of riverine forest and plantations with prime swamp deer habitat (Fig. 8.4-8.7)

Table 8.1 Status of different habitat variables among habitat types in summers

Habitat type	Tree density/ha	Shrub density/ha	Cover percentage			
			Grass	Sedge	Herb	Aquatic flora
Agricultural field	16.44±8.72	0	57.58±14.78	49.52±10.92	77.58±19.28	21.26±6.21
Scrub forest	10.62±4.52	1687.90±538.21	260.83±29.83	6.67±4.49	55.83±9.24	0.83±0.83
Dry grassland	0	174.32±109.18	268.16±18.77	27.11±8.01	9.21±4.12	10.00±5.70
Swamp	0	0	36.08±5.73	46.39±4.55	42.34±6.40	98.16±7.98
Moist deciduous forest	197.64±30.56	3566.88±642.34	78.24±16.49	0	73.97±10.49	0
Plantations	197.15±24.53	430.69±89.42	296.90±19.58	0.24±0.23	82.38±12.05	0.24±0.23
River bank	0	5.54±5.53	63.04±8.09	9.13±1.82	32.61±2.49	13.48±2.46
Riverine forest	46.23±12.94	345.18±107.99	154.84±20.88	4.68±2.63	4.19±2.00	98.71±11.18
Banganga water body	0	0	2.00±2.00	0	1.00±1.00	325.50±16.40
Banganga *Typha* island	0	146.99±146.98	155.38±25.39	92.69±22.81	28.08±9.73	114.23±18.64
Overall	44.28±6.11	592.88±103.98	120.34±7.48	26.97±2.65	42.02±3.52	57.94±4.86

Table 8.2 Status of different habitat variables among habitat types in monsoons

Habitat type	Tree density/ha	Shrub density/ha	Cover percentage			
			Grass	Sedge	Herb	Aquatic flora
Agricultural field	16.44±8.72	0	255.81±15.44	42.74±16.11	4.84±2.14	2.26±1.95
Scrub forest	10.62±4.52	3296.18±950.79	199.13±34.38	8.13±5.18	71.19±16.15	0
Dry grassland	0	462.62±399.42	229.87±11.80	81.71±9.93	67.63±9.15	9.34±3.92
Swamp	0	738.53±342.58	126.20±10.83	76.71±7.05	70.44±9.66	113.99±8.66
Moist deciduous forest	197.64±30.56	9737.73±1032.22	219.47±17.04	17.74±5.24	62.32±8.37	0.88±0.88
Plantations	197.15±24.53	613.78±169.22	227.73±27.90	0	48.64±9.36	0
River bank	0	0	56.74±14.77	0.65±0.35	13.26±8.14	0.43±0.30
Riverine forest	46.23±12.94	156.15±61.87	79.84±19.29	11.13±4.08	3.39±2.01	95.65±10.25
Banganga water body	0	0	5.10±2.67	0	0.60±0.27	130.20±11.43
Overall	44.28±6.11	1499.17±222.15	142.99±6.87	35.75±3.26	40.29±3.42	58.47±4.32

Table 8.3 Status of different habitat variables among habitat types in winters

Habitat type	Tree density/ha	Shrub density/ha	Cover percentage			
			Grass	Sedge	Herb	Aquatic flora
Agricultural field	16.44±8.72	0	114.55±22.39	19.03±7.39	22.58±6.65	21.94±8.07
Scrub forest	10.62±4.52	1825.90±457.56	328.33±15.02	3.67±3.66	41.00±11.21	.00
Dry grassland	0	0	254.08±12.37	25.39±6.62	48.16±7.62	9.87±5.07
Swamp	0	11.43±8.75	25.00±4.03	90.45±4.78	44.23±4.91	106.73±5.64
Moist deciduous forest	197.64±30.56	4780.82±887.18	128.09±19.79	5.88±4.02	41.62±5.48	4.26±2.94
Plantations	197.15±24.53	174.32±19.98	62.79±14.04	0	65.00±20.03	0
River bank	0	0	10.00±2.92	0	0	2.00±1.67
Riverine forest	46.23±12.94	106.84±50.50	48.87±13.40	0	0	13.55±4.65
Banganga water body	0	0	0	0	0.21±0.20	144.79±13.53
Banganga *Typha* island	0	9.80±9.79	116.92±31.07	65.77±26.10	12.31±5.98	73.85±18.60
Overall	44.28±6.11	613.60±125.84	89.48±6.58	30.19±2.80	29.24±2.44	55.54±4.15

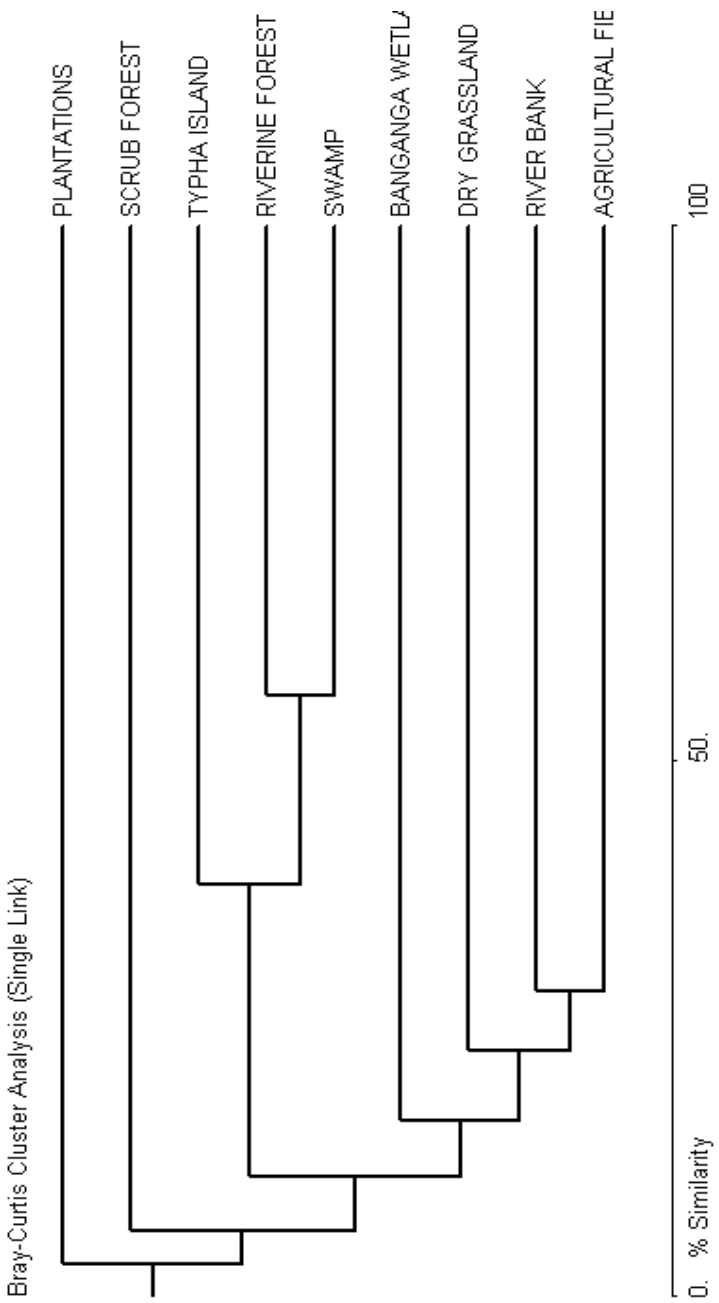


Figure 8.4 Dendrogram showing similarity in composition of aquatic flora between utilized and potential habitat types in summer

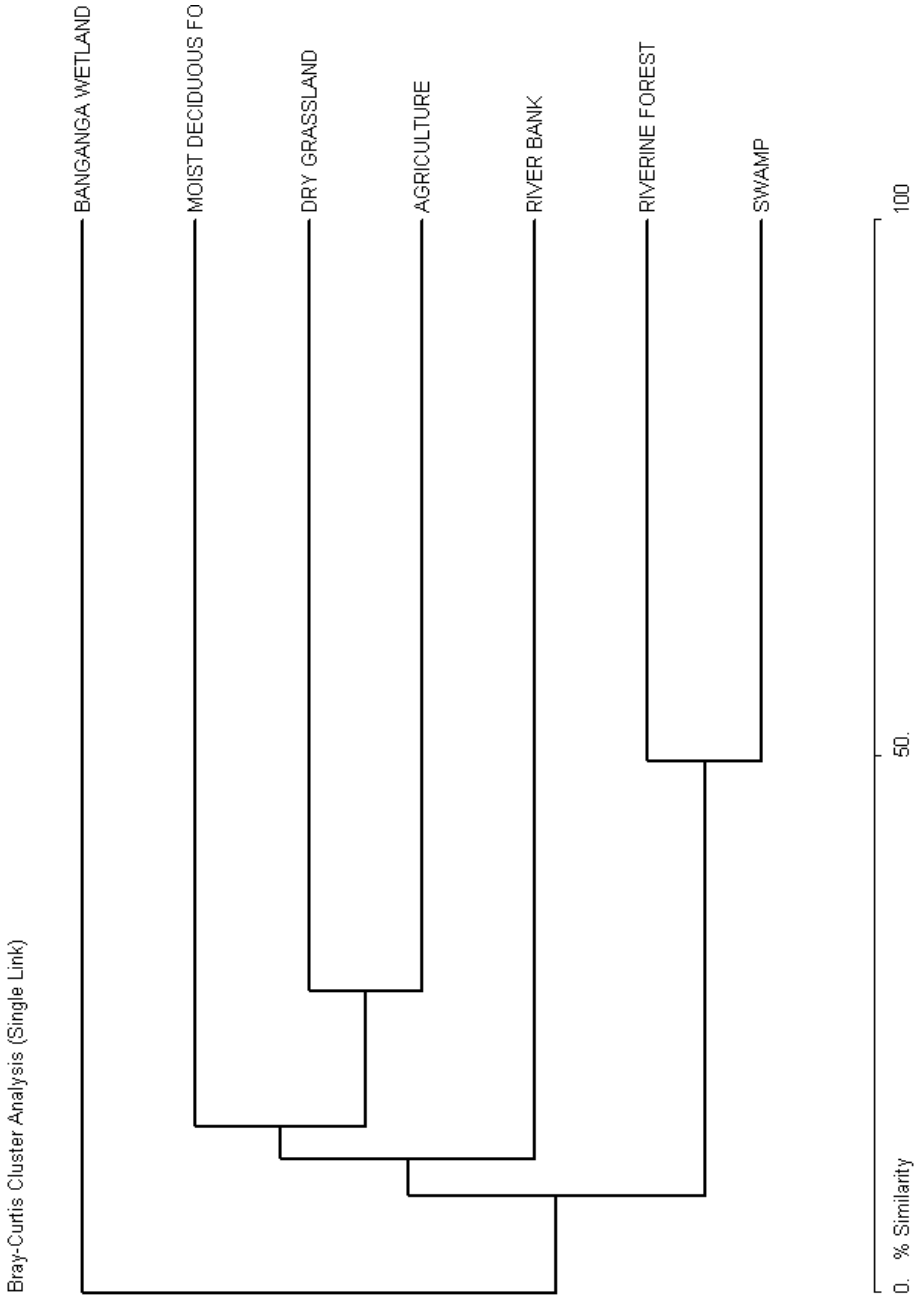


Figure 8.5 Dendrogram showing similarity in composition of aquatic flora between utilized and potential habitat types in monsoon

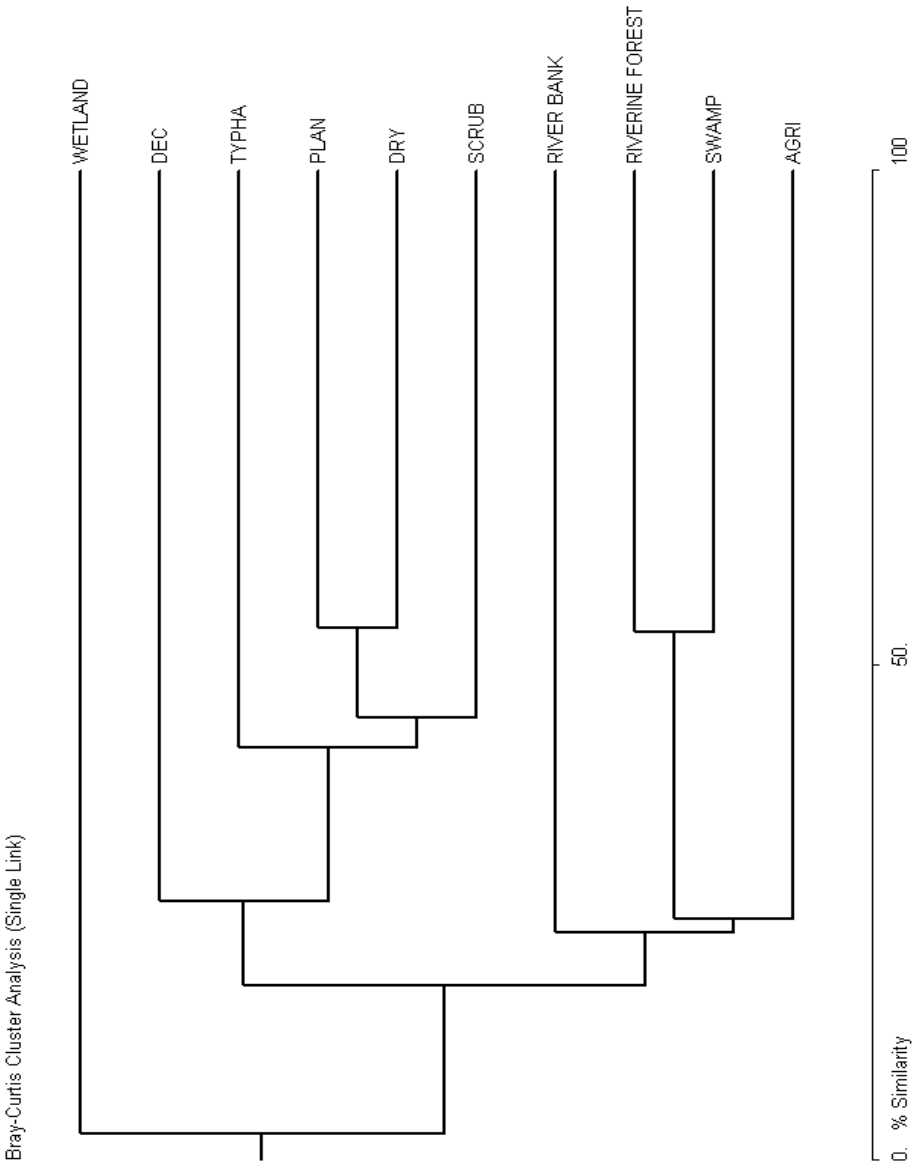


Figure 8.6 Dendrogram showing similarity in composition of grasses between utilized and potential habitat types in summer

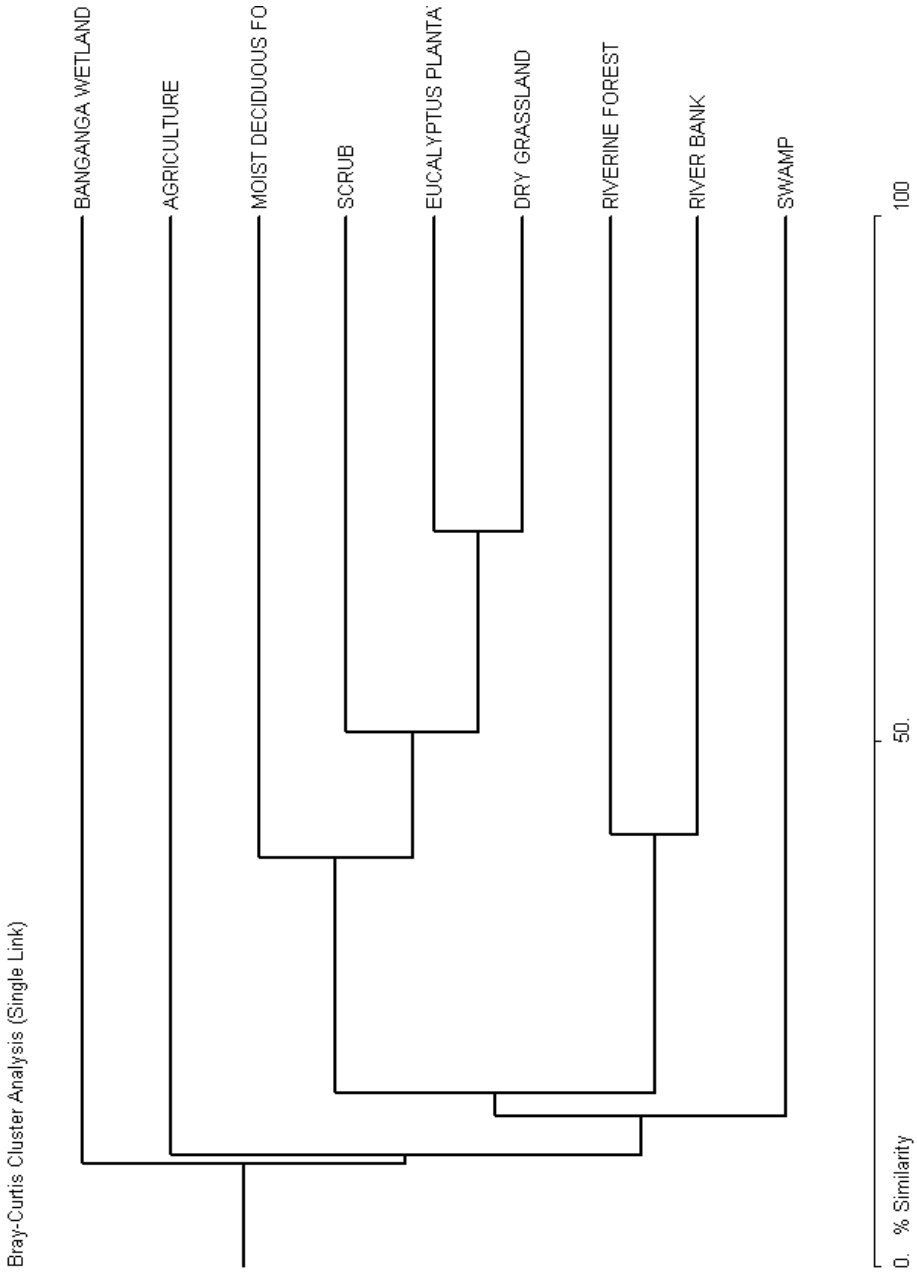


Figure 8.7 Dendrogram showing similarity in composition of grasses between utilized and potential habitat types in monsoon

Results of threat assessment

Table 8.4 provides data on threat factors at different sites. Mean tree cut (no. of trees/plot) in mixed deciduous forest was 2.43±0.67. Mean tree lopping (no. of trees/ plot) was 1.10±0.18. Maximum mean cattle grazing incidences were recorded from scrub forest (7.09±1.16), followed by dry grassland (4.71±0.14), moist deciduous forests (3.01±0.51) and agricultural fields (0.25±0.10) while lowest grazing incidences were recorded from swamp (0.16±0.05). Human presence was found maximum in scrub forest (2.68±0.78), almost equal in agricultural fields (0.79±0.16) and dry grasslands (0.75±0.04), lesser in moist deciduous forest (0.01±0.01) while no one was seen in swamp. Table 8.4 also provides the combined values of threat factors for each habitat type. Scrub forest was found to be the most disturbed habitat as mean threat index was found to be highest (2.44). Least threatened site was found to be swamp (0.04).

Table 8.4 Individual and combined values of all threat variables for each habitat type

Habitat types	Human presence	Cattle grazing incidences	No. of trees lopped	No. of trees cut	Mean threat score
Agricultural fields	0.75±0.04	0.25±0.10	0.00	0.00	0.25
Scrub forest	2.68±0.78	7.09±1.16	0.00	0.00	2.44
Dry grassland	0.79±0.16	4.71±0.14	0.00	0.00	1.38
Swamp	0.00	0.16±0.05	0.00	0.00	0.04
Moist deciduous forest	0.01±0.01	3.01±0.51	1.10±0.18	2.43±0.34	1.64

8.4 Discussions

The results clearly indicate that out of the three visually assumed potential habitat blocks viz. riverine forest, river bank, and plantations; riverine forest bears a close resemblance with the prime swamp deer habitat in term of composition of key habitat variables. That supports our suggestion of habitat expansion by way of including these potential habitat blocks during the course of the management action.

Though in past grass cover composition has been reported by all the authors to be the key habitat variable for swamp deer survival but in the present study aquatic flora was found to be the key habitat variable. This

outcome is supported by the fact that the prime swamp deer habitat at Jhilmil Jheel Conservation Reserve is abundant with aquatic species (106%±3.5%) in comparison to grasses (64%±26%).

Despite the *Typha* swamps of Jhilmil and Banganga wetlands being different from each other in aquatic flora composition, they both form the prime habitats indicating that the swamp deer are not selective for aquatic flora composition.

Discussions regarding threat assessment

Identified threats to the wildlife habitat of Conservation Reserve were excessive dependency of the locals for the fuelwood, fodder, timber, *gujjar deras*, their cattle camps, feral dogs, and extraction of other minor produce (honey collection). A total of 180 households (including those of gujjars staying illegally) were identified in and around the Conservation Reserve area and all are totally dependent on the natural resources of forested land (Plate 8.8-8.9).

Fuelwood collection

Villagers and *gujjars* are totally dependent on the existing forest of Conservation Reserve for fuelwood (Plate 8.10). Survey for the fuelwood was based on the requirements of identified households of both villagers and *gujjars.* All households including *gujjars* were found to be utilizing approximately 4026 kg of fuelwood/ day. Requirement of fuelwood of each family was found to be 45 kg/ day. Villagers are mostly using *Acacia catechu, Alangium salvifolium, Bauhinia variegeta, Bombax ceiba, Cassia fistula, Cordia dichotoma, Dalbergia sissoo, Diospyros Montana, Ehretia laevis,* and *Mallotus phillipensis.*

Fodder extraction

Each household owns a cattle population. The cattle populations are dependent on the fertile hygrophilous and dry grasslands as well as scrub and

deciduous forests for grazing (Plate 8.11). The domestic herbivores prefer almost all kinds of grasses and sedges.

Lopping

In winters, during the period of food crunch the *gujjars* have a practice of collecting tree leaves for fodder (Plate 8.12). The tree species lopped for the purpose are *Acacia catechu, Bombax ceiba, Garuga pinnata, Haldina cordiflolia, Holarrhena antidysentrica, Mitragyna parviflora, Stereospermum chelonoides, Schleichera oleosa,* and *Terminalia bellirica.*

Timber

Villagers depend on woodland and plantations for their timber requirements. They enjoy special rights of the Conservation Reserve to collect wood for their livelihood (Plate 8.13).

Conclusion

Though the results indicate that the threat score of swamp (prime habitat) is minimum but still it is not safe for swamp deer as the adjoining scrub forest has maximum threat score. Thus swamp deer conservation requires long term monitoring, meticulous planning and intensive management action i.e. providing connectivity between prime swamp deer habitat and adjacent habitat blocks.

Although connectivity can be achieved in many ways such as movement through low quality habitat surrounding reserves, here corridor is being advocated as the observations of various authors reveal that swamp deer are extremely human shy and they by no means will use low quality habitats. Here connectivity can be achieved by following steps mentioned below:

(i) Providing connectivity between the potential habitat blocks and core swamp zone of Conservation Reserve by evacuating crop fields of

'Tatwala' village adjoining to the swamp area and the 'gujjar deras' of compartment 7a.

(ii) Developing corridor between Jhilmil Jheel and Banganga Wetlands

Step 1

Relocation of selected crop fields of Tatwala village and '20 gujjar deras'of compartment 7a is crucial to the swamp deer conservation as it shall provide unhindered access to the swamp deer populations right up to the Ganges and will add an area of 18.484 km^2 to the available 2.886 km^2 habitat. The evicted parts of village and agricultural fields would have to be cleaned of village and household debris etc so that the grassland habitat and water bodies are restored. Eventually an area of approximately 21.370 km^2 will be available for conservation purposes, free from all human encumbrances. It is going to be a contiguous habitat dedicated to conservation of terai ecosystem in Uttarakhand.

Step 2

On the western banks of the river Ganges, is located Banganga Wetlands (Fig 8.8) with a small population of swamp deer (approximately 80) (Plate 8.4 - 8.7). Therefore need was felt to suggest measure to ensure a corridor between these two population of swamp deer. The villages on the western bank of river Ganges between the river and Banganga wetland are required to be relocated on a similar pattern as of Jhilmil.

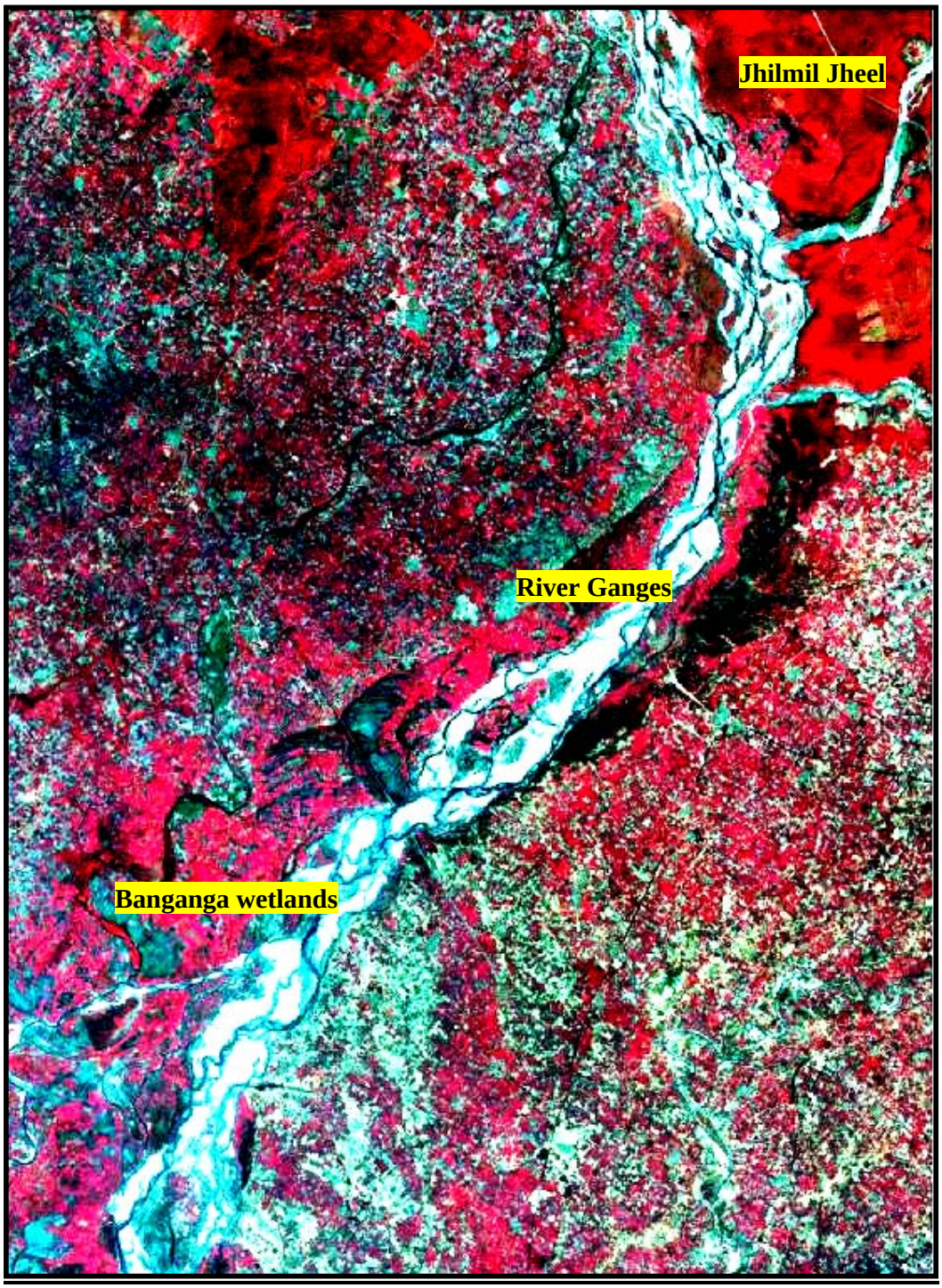


Figure 8.8 Map showing location of Jhilmil Jheel and Banganga Wetland

Plate 8.1 Riverine forest

Plate 8.2 Eucalyptus plantation

Plate 8.3 River bank

Plate 8.4 Banganga Wetland

Plate 8.5 Banganga water body

Plate 8.6 Banganga *Typha* island

Plate 8.7 Swamp Deer at Banganga wetland

Plate 8.8 A number of the *gujjar* household live around prime swamp deer habitat

Plate 8.9 Human habitation

Plate 8.10 People in JJCR, heavily dependent on forests for fuelwood

Plate 8.11 Unchecked cattle grazing degrading the grassland of JJCR

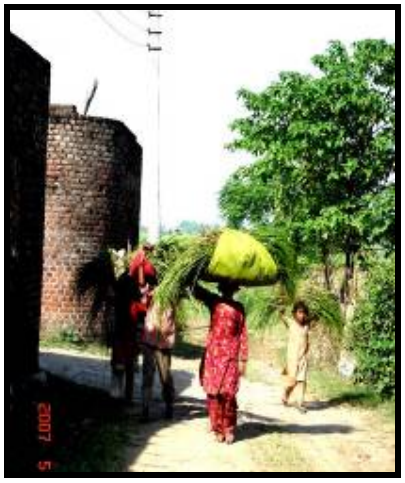


Plate 8.12 Lopping

Plate 8.13 Timber extraction for fencing

Plate 8.14 An *Azolla bipinnata* infested water body

Plate 8.15 Degraded forests

Plate 8.16 Intentional burning in scrub forest

Plate 8.17 Bisleri factory coming up on the boundary of the prime swamp deer habitat

Plate 8.18 Check dam construction at the exit point of drainage from wetland to River Ganga

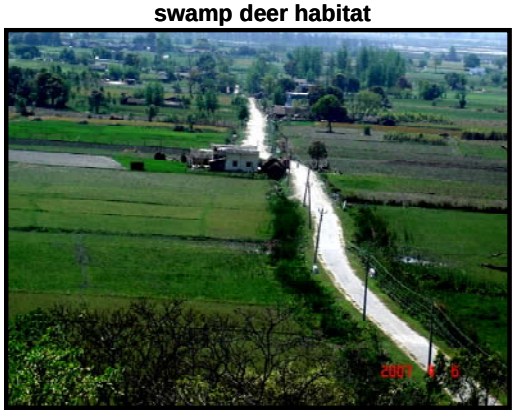


Plate 8.19 Road network inside the reserve fragments the habitat

Chapter 9

Conservation Strategy

CHAPTER 9
CONSERVATION STRATEGY

Introduction

The dependency of local people on the resources of protected areas has often given rise to conflict between the local communities and the wildlife managers. The clash between the dependency of local people and the conservation interest of the protected area has been more counterproductive than to achieve conservation of flagship species through protected area coverage. It has been long recognized that in developing world where the protected areas have high dependency of local people, the conservation of flagship species is possible if the interests of local communities are taken care of. Also increase in conservation awareness of local people is of fundamental importance for long term conservation of protected area values. However in India the protected area managers have ignored the importance of conservation education and eco-development (a term synonymous with removal of dependency of local communities by providing alternatives) activities until recently. This realization gave birth to the concept of Conservation Reserve. It is a reserved forest area declared so to conserve its floral and faunal elements.

In this chapter I will elaborate some specific threats to the area before suggesting conservation measures:

Fuelwood collection: This practice, if is in certain limits may not be detrimental to the habitat but as is realized by conservationists (true for the study area also), this practice often go beyond the threshold and visible signs of deterioration may be see in the habitat.

Lopping: Lopping result in opening of canopy which in turn encourage greater shrub growth. These shrubs here are weeds such as *Adhatoda vasica* and *Lantana camara*. This has negative effects on swamp deer use of the habitats.

Grazing: By virtue of its being the only wetland in the area of its size that remains green and productive throughout the year, it attracts the graziers from

neighboring areas during the summer and is intensively grazed from March to June.

The villagers of the adjoining village, Tantwala: They though never pose any intentional threat to the swamp deer as well as other wild animals. But their regular, unchecked, and uncontrolled utilization of forest resources make them a serious threat to all kind of wildlife in general and swamp deer in particular. The swamp deer as mentioned many a times in the previous chapters are extremely shy by nature and presence of human in any of their habitats deter them from using it.

The *Gujjars*: as it is well known, are transhumant pastoralists who rear large herds of buffaloes and earn their daily fodder and fuel requirements. Earlier they moved to the alpine meadows during the summers thus giving the forests a chance to rejuvenate. However recently they have completely given over this practice and reside in this area throughout the year. They have set up grazing camps in some areas where there is adequate grass for their cattle, which are often situated some distance away from their *deras*. Consequently lopping, firewood collection and grazing within the forests continues through out the year at highly unsustainable levels.

To elaborate, winter forms the only season of lopping by *gujjars*. However, this is a cause of concern since in winters forage availability in moist deciduous forests is maximum (15.65$\pm$0.05) as compared to summers (8.95+0.01) and monsoons (nil). This regular and unrestricted movement of humans into this forest deprive the animal from deriving forage which is significantly more in mixed forest than other habitats (agricultural fields: 8.61$\pm$0.05, scrub: 2.09$\pm$0.01, dry grassland: 8.74$\pm$0.02, swamp: 7.8$\pm$0.02).

Another interesting observation that came to the fore was that there was the presence of extremely heavy livestock grazing pressure and human presence within the *Imperata cylindrica* dominated grassland even though the forage quality did not vary substantially over the winter and summer. These were likely factors that may be responsible for the low abundance of swamp

deer sighted within this grassland during the summer. The area was not only nutritionally very poor but also had a very high degree of disturbance during the summer. Heavy livestock grazing and disturbance regimes may convert this area into a sub-optimal habitat in the long run. This may be of significance when it is clear that Jhilmil Jheel Conservation Reserve is a habitat island amidst a mosaic of human dominated landscape. Each year it experiences a period of resource crunch during the peak summer when the forage quality in all grasslands is poor. Over the years an increasing pressure on available resources by wildlife populations confined to these habitat islands reduces the allowed time during which the habitat can recuperate. Additional competition from livestock for resources such as food, water, and wallowing sites will serve to make the situation critical in the long run. I therefore took up this study and documented the effects of livestock pressure on wild stock.

Suggestions:

1. **Check on livestock grazing in the Conservation Reserve**: Studies conducted by Clark et al (2000) on Elk suggested that livestock grazing affects forage quality of winter range in a negative manner. Similar observations were made during the current study in the Jhilmil Conservation reserve. Hence it is recommended that the grazing of livestock owned by the local community as well as the gujjar community (the nomadic tribes) should be checked by the Reserve Management owing to the fact that these livestock may carry contagious diseases that may be harmful for the Swamp Deer residing in the area (Schaller 1967). The population of livestock also needs to be controlled because livestock has been observed to be sharing resources with the swamp deer which in other word means that the net area available for the swamp deer is much reduced that the original area available in the reserve. Similar studies Austin et al (1986) have shown similar results on Mule Deer. Maximum number of livestock is owned by the approximately 25 families of gujjar communities who are living in the Conservation Reserve area through illegal means. These gujjars have frequently been found to accompany their livestock, but as

swamp deer are shy animals, the presence of human beings hampers the normal activity as well as the critical period of their life like fawning and rutting. Similar studies have been undertaken in Utah by de Vos et al (2003).

Note (1): It has been observed that *gujjar's* livestock being very large in number poses much greater threat to the feeding grounds of swamp deer. In the year 2002, when *gujjars* of Rajaji were translocated, they gave away their cattle to the families like that of Jhilmil area who had larger grazing areas available with them. This has increased the grazing pressure in the recent years.

Note (2): Dependency of the local people on already fragmented wildlife habitat should be reduced by diverting the grazing pressure outside the Reserve area during the period of resource crunch.

2. **Check on flow of cattle dung into the central wetland:** It is also a known fact that the cattle dung hastens the process of hydrosere succession due to eutrophication. Typha is an amphibious plant and it can survive broader range of ecological conditions of the wetland when the water dries up. Hence during dry phases, Typha vegetation tends to take over the other indigenous vegetation of the area. This process is enhanced due to eutrophication; hence year by year Typha vegetation reduces the normal wet grasslands (Miklovic et al 2005).

3. **Check drainage of contaminated water to the swamp**: Most of the nearby field owners have been using innumerable toxic pesticides, insecticides, and weedicides. Water from fields flow to the swamp during rainy seasons, and contaminates the natural swamp water. In long term this is not good for the vegetation as well as swamp deer. (Bakermans et al 2002)

4. **Check on trampling of new sprouts**: Grazing damage caused due to trampling by the movement of heavy livestock. To check this, during monsoon period, when maximum sprouting of seeds occurs, grazing of

livestock in the conservation reserve should be checked (Johnson et al 2003).

5. **Check on wallowing by domestic animals**: Domestic animals like buffaloes have the tendency of wallowing throughout the day in the water holes, especially during summer when there is water scarcity in the reserve. This not only hampers the normal activity of swamp deer but also makes the water unfit for drinking for other wild animals (Hazra 2003).

6. **Check on human activity in the core area of Conservation Reserve**: Human presence along with their heavy and light motor vehicles should be prohibited from the area as the swamp deer is extremely sensitive to human presence.

Note (1): Excess of fuelwood collection can be checked by strong vigil.

Note (2): The villagers need awareness regarding the regeneration time of woody species.

7. **Check on exotic *Lantana camara***: The area has recently been infested by Lantana camara which hampers the natural indigenous vegetation of area. Hence these weeds should be eradicated through Reserve Management (Plate 9.1-9.3).

Note: A Lantana eradication programme was initiated in the year 2007 and showed positive results.

8. **Conservation awareness programmes:** Spreading awareness regarding wildlife conservation in cooperation with eco-development committee of the area would be of immense help (Plate 9.4).

Plate 9.1 Uprooting of *Lantana camara*

Plate 9.2 Ploughing done to raise native grass species

Plate 9.3 *Lantana* eradication training

Plate 9.4 Wildlife week organized at Rasiabadh Forest Rest House, JJCR

Plate 9.5 Controlled burning by the Forest Department before fire season

Plate 9.6 Gully plugging to maintain water level in central wetland

Other management interventions

Plate 9.7 Improved wildlife habitat

Plate 9.8 Leopard kill at JJCR

Plate 9.9 Increased wildlife sightings

Probable effects of management interventions

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Appendices

APPENDIX 1: FLORA OF JHILMIL JHEEL CONSERVATION RESERVE (JJCR)

Botanical name	Habit	Local name	Remarks	Habitat
ACANTHACEAE				
Barleria sp.	he	-	-	MDF
Hemigraphis hirta (Vahl.) T. Anderson	he	-	-	MDF
Hemigraphis latebrosa (Heyne ex Roth.) Nees	he	-	-	Sw
Hemigraphis rupestri Heyne ex T. Anderson	he	-	-	MDF
Hygrophila polysperma (Roxb.) T. Anderson	aq	-	-	Sw
Hygrophila salicifolia (Vahl.) Nees	aq	-	-	Sw
Justicia quinqueangularis Koenig ex Roxb.	he	-	-	Sw
Justicia simplex D. Don	he	-	-	Sw
Nelsonia canescens (Lam.) Spreng.	he	-	-	RB
Perilepta auriculata (Nees) Bremek.	he	-	-	MDF
Peristrophe sp.	he	-	-	Agri
Rungia pectinata (L.) Nees	he	-	-	MDF
Adhatoda vasica Nees	he	Basing	For ripening of fruits	MDF
Dicliptera roxburghiana Nees	he	-	-	MDF
AIZOACEAE				
Trianthema portulacastrum L.	he	-	edible	Agri
ALANGIACEAE				
Alangium salvifolium (L. f) Wang.	tr	Koelee	Fuelwood	MDF
ALISMATACEAE				
Sagittaria trifolia L. (Syn: *Sagittaria sagittifolia* L.)	aq	Bhanwaar	Wild edible fruit	Sw
AMARANTHACEAE				
Achyranthes aspera L.	he	Patkanda	Weed, Snake bite,	MDF
Aerva lanata (L.) Juss. ex Schult.	he	Kharentee	Cattle feed	MDF
Alternanthera sessilis (L.) R. Br. ex DC	aq	-	-	Sw
Digera muricata (L.) Mart.	he	-	-	Agri
Gomphrena celosioides Mart.	he	-	-	DG
Pupalia lappacea (L.) Juss.	he	-	-	Pl
ANACARDIACEAE				
Lannea coromandelica (Houtt) Merr.	tr	Jhingan	Fuelwood	MDF
ANNONACEAE				
Miliusa velutina (Dunal) Hook. f. & Thomson	tr	Doomsaal	Fuelwood	MDF
APIACEAE				
Centella asiatica (L.) Urban	he	-	-	Pl
Hydrocotyle sibpthorpioides Lam.	aq	-	-	Sw
Oenanthe javanica (Blume) DC.	he	-	-	Sw
Psamogeton canescens (DC) Vatke.	aq	-	-	Sw
APOCYNACEAE				
Asclepias curassavica L.	he	-	-	Agri
Calotropis procera (Aiton) R. Br.	sh	Aak	-	MDF
Carissa carandas L.	sh	Karonda	wild edible fruit	MDF
Carissa opaca Stapf ex Haines	sh	-	wild edible fruit	MDF
Holarrhena antidysentrica Wallich	tr	Koora, Kokat	Fuelwood, lopped	MDF

Ichnocarpus frutescens (L.) R.Br.	cl	-	-	MDF
Nerium indicum Mill.	sh	-	-	MDF
Vallaris solanacea (Roth) Kuntze.	cl	-	-	MDF
ARACEAE				
Acorus calamus L.	aq	Bach	Medicinal value	Sw
ARECAEAE				
Calamus tenius	cl	Baent	Basket making	SF
Phoenix sylvestris(L.) Roxb.	tr	Khajoor	-	MDF
ASPARAGACEAE				
Asparagus adscendens Roxb.	he	-	-	MDF
ASTERACEAE				
Ageratum conyzoides L.	he	Pudina booty	Weed	Agri
Blainvillea acmella (L.) Philipson	he	-	-	Sw
Blumea lacera (Burm. f.) DC.	he	-	weed	Agri
Caesulia axillaris Roxb.	he	-	-	Sw
Cichorium intybus L.	he	-	-	Agri
Eclipta prostrata (L.)	he	Bhangra	-	Sw
Emilia sonchifolia (L.) DC.	he	-	-	Agri
Erigeron sp.	he	-	-	RB
Gnaphalium pensylvanicum Willd.	he	-	-	RB
Gnaphalium polycaulon Pers.	he	-	-	MDF
Launaea procumbens(Roxb.) Ramayya & Rajagopal	he	-	-	Pl
Myriactis wallichii Less.	he	-	-	Sw
Parthenium hysterophorus L.	he	Gajar ghaas	-	MDF
Pulicaria crispa (Forssk.) Benth.	he	-	-	RB
Silybum marianum (L.) Gaertn.	he	Dudhlee rus	Cattle feed	MDF
Sonchus arvensis L.	he	Duddhy booty	Cattle feed	Agri
Sonchus asper (L.) Hill	he	Duddhy booty	Cattle feed	Agri
Vernonia cinerea (L.) Less.	he	-	-	MDF
*Xanthium strumarium*L.	sh	Jhinjhra	Weed	Sw
Youngia japonica (L.) DC.	he	-	-	Pl
BIGNONIACEAE				
Oroxylum indicum (L.) Venten.	tr	Talwar phali	-	Agri
Stereospermum chelonoides (L. f.) DC.	tr	Paadal	Fuelwood, lopped	MDF
BORAGINACEAE				
Cordia dichotoma G. Forster.	tr	Lisora	Wild edible fruit	MDF
Cordia obliqua Willd.	tr	Lisora	Fuelwood	MDF
Ehretia laevis Roxb.	tr	Chamror	Fuelwood	MDF
Heliotropium strigosum Willd.	he	-	-	MDF
BRASSICACEAE				
Coronopus didymus (L.) Sm.	he	-	-	Agri
Rorippa nasturtium-aquaticum (L.) Hayek	aq	-	-	Sw
BURSERACEAE				
Garuga pinnata Roxb.	tr	Kharpat	Fuelwood, lopped	MDF
CACTACEAE				
Opuntia stricta (Haw.) var. *dillenii* (Ker Gawl.) Benson	he	Nagphani	Live hedge	MDF
CAMPANULACEAE				
Campanula benthamii Wall. ex DC.	he	-	-	RB
CANNABACEAE				
Cannabis sativa L.	he	Bhaang	Intoxicant	SF

CAPPARACEAE				
Capparis sepiaria L.	sh	-	wild edible fruit	MDF
Capparis zeylanica L.	sh	-	wild edible fruit	MDF
Cleome gynandra L.	he	-	-	RB
Crateva religiosa var. *roxburghii* (R. Br.) Hook. f.	tr	Barna	Fuelwood	MDF
CARYOPHYLLACEAE				
Silene sp.	he	-	Weed	Agri
CELASTRACEAE				
*Celastrus paniculatus*Willd.	sh	Koi	-	MDF
CERATOPHYLLACEAE				
Ceratophyllum demersum L.	aq	-	weed	RB
CHENOPODIACEAE				
Chenopodium album L.	he	Janglee bathua	-	RB
Chenopodium ambrosoides L.	he	Janglee bathua	Edible	RB
COMBRETACEAE				
Anogeissus latifolia (Roxb. ex DC.)	tr	Dhaura	Fuelwood	MDF
Terminalia alata Heyne ex Roth.	tr	Sain	Fuelwood	MDF
Terminalia arjuna (Roxb. ex DC.) Wight & Arnott	tr	Arjun	Fuelwood	MDF
Terminalia bellirica Roxb.	tr	Bahera	Fruit is a laxative, lopped	MDF
COMMELINACEAE				
Commelina benghalensis L.	he	-	Cattle feed	MDF
Commelina longifolia Lam.	he	Bail ghaas	Weed	Agri
Cyanotis cristata (L.) D. Don	he	-	-	Sw
Tonningia axillaris (L.) Kuntze	he	-	-	Agri
CONVOLVULAVEAE				
Cuscuta reflexa Roxb.	cl	Akash bel	-	MDF
Evolvulus nummularius (L.) L.	he	-	-	MDF
Ipomoea carnea Jacq.	sh	Besharam	Hedge row	Sw
Ipomoea nil (L.) Roth	cl	-	-	MDF
Ipomoea pes-tigridis L.	he	-	-	Pl
Ipomoea sp.	he	-	-	MDF
CUCURBITACEAE				
Coccinia grandis (L.) Voigt.	cl	Janglee kaduu	-	SF
Cucumis hardwickii Royle	he	-	-	SF
Melothria maderaspatana (L.) Cogn.	cl	-	Weed	Agri
Momordica dioica Roxb. ex Willd.	cl	Janglee karelaa	wild edible fruit	Sw
Trichosanthes sp.	cl	Kandooree bail	Weed	Agri
Zehneria scabra (L. f.) Soud	cl	-	-	Pl
CYPERACEAE				
Carex myosurus Nees	sed	Dilla	Cattle feed, food plant	Sw
Carex sp.	sed	Dilla	Cattle feed	Sw
Cyperus alopecuroides Rottb.	sed	Dilla	cattle feed	Agri
Cyperus brevifolius(Rottb.) Hassak.	sed	Motha	Cattle feed, food plant	Sw
Cyperus compressus L.	sed	Dilla	Cattle feed	Sw
Cyperus cyperoides (L.) Kuntze	sed	Dilla	Cattle feed, food plant	Sw

Cyperus iria L.	sed	Dilla	Cattle feed	Sw
Cyperus kyllingia Endl.	sed	Motha	Cattle feed, food plant	Sw
Cyperus niveus Retz.	sed	Motha	cattle feed	Pl
Cyperus nutans Vahl.	sed	Dilla	Cattle feed	Sw
Cyperus rotundus L.	sed	Buin	Cattle feed, food plant	Agri
Elaeocharis sp.	sed	-	cattle feed	Sw
Elaeocharis tetraquetra Nees	sed	-	Cattle feed	Sw
Fimbristylis ascicularis R. Br.	sed	-	Cattle feed	Sw
Fimbristylis dichotoma (L.) Vahl	sed	-	Cattle feed, food plant	Sw
Fimbristylis miliacea (L.) Vahl	sed	-	Cattle feed, food plant	Sw
Fimbristylis sp.	sed	Dilla	-	Sw
Scirpus lateriflorus Gmel.	sed	Motha	Cattle feed	Sw
Scirpus sp.	sed	Motha	Cattle feed	Sw
EBENACEAE				
Diospyros montana Roxb.	tr	Bishtendu	Fuelwood	MDF
EQUISETACEAE				
Equisetum ramosissimum Desf.	pte	Jortor	For curing arthritis	DG
ERIOCAULACEAE				
Eriocaulon sp.	sed	-	-	DG
EUPHORBIACEAE				
Balinospermum montanum (Willd.) Muell. Arg.	sh	-	-	MDF
Euphorbia hirta L.	he	Dad kaat	Weed	MDF
Mallotus phillipensis (Lamk.) Muell-Arg	tr	Rainee	Fuelwood	MDF
Putranjiva roxburghii Wall.)	tr	Jiyaputa	For child health	MDF
Sapium sebiferum Roxb.	tr	Tarcharbee	-	SF
Trewia nudiflora L.	tr	Gutel	Fencing	MDF
Ricinus communis L.	sh	Arandee	Cure for swelling	MDF
FABACEAE				
Acacia nilotica (L.) Delile	tr	Khejri	-	MDF
Alysicarpus bupleurifolius (L.) DC.	he	-	-	Sw
Alysicarpus monolifer (L.) DC.	he	-	-	Agri
Alysicarpus vaginalis (L.) DC.	he	-	-	Sw
Bauhinia racemosa Lam.	tr	Kachnari	wild edible fruit	MDF
Butea monosperma (Lam.) Taub.	tr	Dhak	Fuelwood	MDF
Crotalaria medicaginea Lam.	he	-	-	MDF
Dalbergia sissoo Roxb.	tr	Shisham	Fuelwood	MDF
Desmodium gangeticum (L.) DC.	he	-	-	SF
Desmodium trifolium (L.) DC.	he	-	-	SF
Desmodium velutinum (Willd.) DC.	he	-	-	RB
Erythrina suberosa Roxb.	tr	-	-	MDF
Medicago lupulina L.	he	-	Food plant	SF
Medicago polymorpha L.	he	-	Weed	Agri
Melilotus alba Medik. ex Desr.	he	-	-	Agri
Melilotus indica L.	he	Mureilaa	Cattle feed	Agri
Millettia extensa (Benth.) Benth. ex Baker	cl	Goj bel	-	MDF
Mucuna pruriens (L.) DC.	cl	Kauch	-	MDF
Pongamia pinnata (L.) Peirre	tr	-	-	MDF
Sesbania bispinosa (Jacq.) W. F. Wight	he	-	weed	Agri
Sesbania grandiflora (L.) Poir.	he	-	weed	Agri
Smithia conferta Sm.	he	-	-	Sw
Smithia sensitiva Aiton	he	-	-	Sw

Streblus asper Lour.	tr	Mirchoo	Fuelwood	MDF
Tephrosia candida DC.	he	-	-	MDF
Trifolium tomentosum L.	he	Chatala	Cattle feed	Agri
Uraria rufescens (DC.) Schindl.	he	-	-	PI
Vigna vexillata (L.) A. Rich.	cl	-	-	Sw
Abrus precatorius L.	cl	Ratti	Sweetening of paan	MDF
Acacia catechu Willd.	tr	Khair	Fuelwood, lopped	MDF
Albizia lebbeck (L.) Benth.	tr	Siris	Fuelwood	MDF
Albizia procera (Roxb.) Benth.	tr	safed siris	Fuelwood	MDF
Bauhinia malabarica Roxb.	tr	Khatwa	Wild edible fruit	MDF
Bauhinia variegeta L.	tr	Kachnaar	Fuelwood	MDF
Cassia fistula L.	tr	Amaltaas	Fuelwood	MDF
Cassia occidentalis L.	sh	Panwaar	Branches used in cremation	MDF
Cassia tora L.	he	Elma	Medicine for cattle	MDF
Holoptelia integrifolia (Roxb.) Planch.	tr	Kanjoo	Fuelwood	MDF
Mimosa pudica L.	he	Chui mui	-	MDF
Tephrosia purpurea (L.) Pers.	he	-	-	MDF
Vicia sativa L.	cl	Roree	Cattle feed	SF
Prosopis cineraria (L.) Druce	sh	-	-	MDF
FLACOURTIACEAE				
Casearia tomentosa Roxb.	tr	Chilla	Fuelwood	MDF
Flacourtia indica (Burm. f.)Merr.	tr	Kangu	Fuelwood	MDF
FUMARIACEAE				
Fumaria indica (Hausskn.) Pugsley	he	Papra	Weed	Agri
GENTIANACEAE				
Centaurium centaurioides (Roxb.) Rao et Hemadri	he	-	-	Agri
HYACINTHACEAE				
Urginea indica (Roxb.) Kunth)	he	-	-	MDF
HYDROCHARITACEAE				
Hydrilla verticillata (L. f.) royle.	aq	-	-	Sw
JUNCACEAE				
Juncus bufonius L.	sed	Motha	Cattle feed	Sw
LAMIACEAE				
Leonotis nepetifolia (L.) R.Br.	he	-	-	PI
Leucas cephalotus (Koenig ex Roth) Spreng.	he	-	-	PI
Mosla dianthera (Buch.-Ham.) Maxim.	he	Tulsa	Flavouring agent for tea	Sw
Nepeta sp.	he	-	-	Agri
Ocimum americanum L.	he	Tulsi	For cough treatment	Sw
Perilla frutescens (L.) Britt.	he	-	-	MDF
*Pogostemon benghalense (Burm.f.)*Kuntze	aq	-	-	Sw
Salvia sp.	he	-	Weed	Agri
LAURACEAE				
Litsea glutinosa (Lour.) Robinson	tr	Maida lakdee	For healing fracture	MDF
LENTIBULARIACEAE				
Utricularia sp.	aq	-	-	Sw
LINACEAE				
*Linum usitatissimum*L.	he	Sun	Making ropes	RB
LYTHRACEAE				
Ammania baccifera L.	he	-	weed	Agri
Ammania sp.	he	-	Weed	Agri
Lagerstroemia parviflora Roxb.	tr	-	-	RB

Rotala sp.	he	-	-	Sw
MALVACEAE				
Abutilon indicum (L.) Sweet	he	-	-	MDF
Bombax ceiba L.	tr	Simbal	Wild edible fruit, Fuelwood	MDF
Corchorus aestuans L.	cl	Chunchia bail	Weed	Agri
Corchorus olitorius L.	he	-	Weed	Agri
Kydia calycina Roxb.	tr	poola	Fuelwood	MDF
Malva parviflora L.	he	-	-	Agri
Malvastrum coromandelianum (L.) Garcke	he	Kanghee	-	MDF
Sida acuta Burm. f.	he	Kharentee	-	MDF
Sida rhombifolia L.	he	Kharentee	Curing eczema	MDF
Urena lobata L.	he	Barchita	-	SF
MELIACEAE				
Azadirachta indica A. Juss.	tr	Neem	Medicinal value	MDF
Melia azedarach L.	tr	Dek	Medicinal value	MDF
Murraya koenigii (L.) Spreng.	he	Jalneem	Flavouring agent	MDF
MENISPERMACEAE				
Cissampelos pareira L.	cl	Meerbasi	For curing scorpion bite	MDF
Cocculus hirsutus (L.) Diels	sh	-	-	MDF
Tinospora cordifolia (Willd.) Hook. f. & Thomson	cl	Giloe	-	Pl
MORACEAE				
Broussonetia papyrifera Venten.	tr	Paper mulberry	-	SF
Ficus benghalensis L.	tr	Bar	Worshipped	MDF
Ficus palmata Forssk.	tr	Kaimree	Wild edible fruit	Sw
Ficus racemosa L.	tr	Gular	wild edible fruit	MDF
Ficus religiosa L.	tr	Peepal	Worshipped, lopped	MDF
Ficus rumphii Blume	tr	Pilkhan	Fuelwood	MDF
Morus alba L.	tr	Shehtoot	Wild edible fruit	SF
MYRSINACEAE				
Myrsine africana L.	tr	Borang	Fuelwood	MDF
MYRTACEAE				
Syzygium cumini (L.) Skeels	tr	Jamun	Edible fruit	Sw
Psidium guajava L.	tr	Amrood	Edible fruit	SF
NAJADACEAE				
Najas graminea Del.	aq	-	-	Sw
NYCTAGINACEAE				
Boerrhavia diffusa L.	he	-	-	MDF
NYMPHAEACEAE				
Nymphoides cristata (Roxb.) Kuntze	aq	-	-	Sw
ONAGRACEAE				
Ludwigia adscendens (L.) Hara	aq	-	-	Sw
Ludwigia octavalvis (Jacq.) Raven	aq	-	-	Sw
Oenothera rosea (L.) Herit. ex Ait.	he	-	-	Agri
ORCHIDACEAE				
Pachystoma pubescens Blume	or	-	-	RB
Zeuxine strateumatica (L.) Schl.	or	-	-	Sw
OXALLIDACEAE				
Oxalis corniculata L.	he	Khataree	Food plant	Sw
PAPAVERACEAE				
Argemone mexicana L.	he	-	Weed	DG
Cryptolepis buchanani Roem. & Schult.	cl	-	-	MDF
PHYLLANTHACEAE				

Bridelia retusa (L.) Spreng.	tr	-	-	MDF
Emblica officinalis Gaertn.	tr	Amla	Edible fruit	MDF
Kirganelia reticulata(Poir.) Baill.	tr	-	-	MDF
Phyllanthus urinaria L.	he	-	-	Sw
PIPERACEAE				
Peperomia pellucida L.	he	-	-	Pl
POACEAE				
Apluda mutica L.	gr	Seenkla	Cattle feed, food plant	SF
Brachiaria ramosa (L.) Stapf.	gr	-	-	MDF
Brachiaria sp.	gr	-	-	MDF
Chloris dolichostachya Lagasca	gr	-	Cattle feed	MDF
Chrysopogon fulvus (Spreng.) Chiov.	gr	-	cattle feed	SF
Chrysopogon sp.	gr	Doobra	Cattle feed, food plant	SF
Coix lacryma-jobi L.	gr	Garel	Cattle feed, food plant	Sw
Cymbopogon sp.	gr	-	-	SF
Cynodon dactylon (L.) Pers.	gr	Doob	Cattle feed, food plant	DG
Cynoglossum sp.	gr	Doobra	Cattle feed, food plant	SF
Cyrtococcum accrescens (Trin.) Stapf	gr	Phulla ghaas	Cattle feed, food plant	Sw
Dactylis glomerata L.	gr	-	-	Pl
Dactyloctenium aegyptium (L.) Willd.	gr	-	-	MDF
Dendrocalamus strictus (Roxb.) Nees	gr	Baans	-	MDF
Desmostachya sp.	gr	Dab	Cattle feed, food plant	MDF
Digitaria sanguinalis (L.) Scop.	gr	-	-	Agri
Echinochloa colona (L.) Link	gr	Jhantoo	Cattle feed	Agri
Eleusine indica (L.) Gaertn.	gr	-	Cattle feed	Agri
Eragrostis gangetica (Roxb.) Steud.	gr	-	Cattle feed	RB
Eragrostis stenophylla Hochst. ex Miq.	gr	-	Cattle feed	Sw
Eragrostis unioloides (Retz.) Nees ex Steud.	gr	-	-	RB
Hemarthria compressa (L. f.) R. Br.	gr	-	-	MDF
Imperata cylindrica (L.) Raeuschel.	gr	Sirva	Cattle feed, food plant	DG
Ischaemum indicum (Houtt.) Merr.	gr	Madana	Cattle feed	MDF
Lepidagathis sp.	gr	-	-	Sw
Oplismenus burmanii (Retz.) P. Beauv.	gr	Chirwal	-	MDF
Oplismenus compositus (L.) P. Beauv	gr	Chirwal	Cattle feed	MDF
Panicum capillare L.	gr	-	Weed	Agri
Paspalidium flavidium (Retz.) A. Camus	gr	-	Cattle feed, food plant	MDF
Paspalidium sp.	gr	Doobra	Cattle feed	Agri
Paspalum conjugatum Berg.	gr	Jonkee ghaas	Cattle feed	Agri
Paspalum scrobiculatum L.	gr	Doobra	Cattle feed, food plant	Sw
Pennisetum glaucum (L.) R. Br.	gr	Gulli ghaas	Food plant	Sw
Phalaris minor Retz.	gr	Gulli danda	Cattle feed	Agri
Phragmites karka(Retz.) Trin. ex Steud.	gr	Naree	Cattle feed, food plant	Sw
Phragmites sp.	gr	Naree	Cattle feed	MDF

Poa annua L.	gr	-	-	Agri
Polypogon fugax Nees ex Steud.	gr	-	Cattle feed, food plant	Agri
Saccharum bengalense Retz.	gr	Kanna	Thatching	RB
Saccharum narenga (Nees ex steud.) Hack	gr	-	Cattle feed	MDF
Saccharum spontaneum L.	gr	Kaans	Cattle feed, food plant	SF
Setaria glauca (L.) Beauv.	gr	Gulli ghaas	Cattle feed, food plant	DG
Setaria verticillata (L.) P. Beauv.	gr	Gulli ghaas	Cattle feed, food plant	Agri
Sporobolus diander (Retz.) P. Beauv.	gr	-	Cattle feed	RB
Themeda sp.	gr	-	-	RB
Vetiveria zizanioides (L.) Nash	gr	Panee	Cattle feed, food plant	DG
POLOGONACEAE				
Polygonum barbatum L.	aq	-	-	Sw
Rumex dentatus L.	he	-	Cattle feed	Agri
Rumex hastatus L.	he	-	-	RB
Rumex nepalensis Spreng.	he	-	-	RB
PONTEDERIACEAE				
Monochoria sp.	aq	Bhanwaar	Wild edible fruit	Sw
PORTULACACEAE				
Portulaca sp.	he	-	-	Agri
POTAMAGETONACEAE				
Potamogeton crispus L.	aq	-	-	Sw
Potamogeton nodosus Poir.	aq	-	-	Sw
PRIMULACEAE				
Anagalis arvensis L.	he	-	Weed	Agri
PTERIDACEAE				
Adiantum edgeworthii Hook.	pte	-	-	MDF
Adiantum sp.	pte	-	-	MDF
RANUNCULACEAE				
Ranunculus sceleratus L.	aq	Chignee booty	-	Sw
Zizyphus mauritiana Lam.	tr	Ber	Wild edible fruit	SF
Zizyphus oenoplia (L.) Mill.	tr	Katbaeree	Wild edible fruit	MDF
Zizyphus xylopyra (Retz.) Willd.	tr	Van baeree,bhander	Wild edible fruit	MDF
Potentilla supina L.	aq	-	-	Sw
Rubus ellipticus Smith	sh	Einchu	wild edible fruit	SF
Borreria articularis (L. f.) F.N. Williams	he	-	-	Sw
Catunaregam spinosa (Thunb.) Tirveng.	sh	Makoo	Wild edible fruit	MDF
Haldina cordifolia (Roxb.) Ridsd.	tr	Haldu	Fuelwood, lopped	MDF
Mitragyna parviflora (Roxb.) Korth.	tr	Kaim	Fuelwood, lopped	MDF
Wendlandia heynei (Roem. & Schult.) Sant. & Merch.	sh	-	-	MDF
RUTACEAE				
Aegle marmelos (L.) Correa	tr	Bel	Wild edible fruit	MDF
Hesperethusa crenulata (Roxb.) M. Roem.	tr	Kathbel	Fuelwood	MDF

Limonia acidissima L.	sh	-	-	MDF
SALICACEAE				
Salix tetrasperma Roxb.	tr	Jalmala	Thermal cover	Sw
SAPINDACEAE				
Sapindus mukorossii Gaertn.	tr	Reetha	Country made soap	MDF
Schleichera oleosa (Lour.) Oken	tr	Kachaamb	edible fruit, lopped	MDF
SCROPHULARIACEAE				
Bacopa monnieri (L.) Wettst.	aq	Bhangra	-	Sw
Bacopa procumbens (Miller) Greenm.	he	-	-	RB
Limnophila rugosa (Roth) Merr.	he	-	-	DG
Lindernia anagallis (Burm. f.) Pennell	he	-	-	MDF
Mazus pumilus (Burm. f.) Steenis	he	-	-	RB
Scoparia dulcis L.	he	-	-	RB
Veronica anagalis-aquatica L.	aq	-	-	Sw
SOLANACEAE				
Datura metel L.	he	Dhatura	-	MDF
Nicotiana plumbaginifolia Viv.	he	-	Weed	Agri
Physalis minima L.	cl	Bhambhora	Weed	Agri
Solanum nigrum L.	he	Bhambhoraa	Weed	Agri
Solanum sp.	he	-	-	Pl
Solanum viarum Dunal	he	Safed bhindi	-	SF
STERCULIACEAE				
Helicteres isora L.	sh	Kapasi	Hedge row, thatching	MDF
TAMARICACEAE				
Tamarix aphylla (L.) H.Karst.	tr	-	-	RB
THYLEPTERIDACEAE				
Goniopteris sp.	pte	Morpankhee	-	SF
Thelypteris dentata (Forssk.) E. St. John.	pte	-	-	SF
TYHPACEAE				
Typha angustifolia L.	aq	Patera	Food plant, Thatching,	Sw
Typha elephantina Roxb.	aq	Pateree	Food plant, Thatching,	Sw
ULMACEAE				
Celtis tetrandra Roxb.	tr	Kharik	Fuelwood	Sw
URTICACEAE				
Pouzolzia pentandra (Roxb.) Benn.	aq	-	-	Sw
Pouzolzia zeylanica (L.) Benn.	he	-	-	RB
VERBENACEAE				
Callicarpa macrophylla Vahl.	sh	-	-	RB
Clerodendrum viscosum Venten.	sh	-	Weed	MDF
Gmelina arborea Roxb.	tr	-	-	SF
Phyla nodiflora (L.) Greene	he	Peepalbhatt	Weed	Agri
Stachytarpheta jamaicensis (L.) Vahl.	he	-	-	Pl
Lantana camara L.	sh	Lalten	Weed	SF
VIOLACEAE				
Viola betonicifolia Sm.	he	-	-	SF
ZINGIBERACEAE				
Curcuma aromatica Salisb.	he	Janglee haldi	-	MDF

Aq = Aquatic species, cl = climber, gr = grass, he = herb, or = orchid, pte = pteridophyte, sed = sedge, sh = shrub, tr = tree, agri = agricultural fields, DG = dry grassland, MDF = moist deciduous forest, Pl = plantation, RB = river bank, SF = scrub forest, Sw = swamp

APPENDIX 2: SOME COMMON AVIFAUNA OF JJCR

Common Name	**Scientific name**
Black francolin	*Francolinus francolinus*
Painted francolin	*Francolinus pictus*
Grey francolin	*Francolinus pondicerianus*
Swamp francolin	*Francolinus gularis*
Common quail	*Coturnix coturnix*
Japanese quail	*Coturnix japonica*
Rain quail	*Coturnix coromandelica*
Blue-breasted quail	*Coturnix chinensis*
Jungle bush quail	*Perdicula asiatica*
Small buttonquail	*Turnix sylvatica*
Yellow-legged buttonquail	*Turnix tanki*
Barred buttonquail	*Turnix suscitator*
Red spurfowl	*Galloperdix spadicea*
Painted spurfowl	*Galloperdix lunulata*
Red junglefowl	*Gallus gallus*
Grey junglefowl	*Gallus sonneratii*
Indian peafowl	*Pava cristatus*
Bean goose	*Anser fabalis*
Greater white-fronted goose	*Anser albifrons*
Greylag goose	*Anser anser*
Lesser whistling-duck	*Dendrocygna javanica*
Ruddy shelduck	*Tadorna ferruginea*
Common shelduck	*Tadorna tadorna*
Cotton pygmy-goose	*Nettapus coromandelianus*
Gadwall	*Anas strepera*
Falcated duck	*Anas falcata*
Eurasian wigeon	*Anas penelope*
Spot-billed duck	*Anas poecilorhyncha*
Common teal	*Anas crecca*
Northern shoveler	*Anas clypeata*
Brown-capped pygmy woodpecker	*Dendrocopos nanus*
Yellow-crowned woodpecker	*Dendrocopos mahrattensis*
Streak-throated woodpecker	*Picus xanthopygaeus*
Black-rumped flameback	*Dinopium benghalense*
Greater flameback	*Chrysocolaptes lucidus*
White-naped woodpecker	*Chrysocolaptes festivus*
Great Barbet	*Megalaima virens*
Brown-headed barbet	*Megalaima zeylanica*

Coppersmith barbet	*Megalaima haemacephala*
Indian grey hornbill	*Ocyceros birostris*
Oriental pied hornbill	*Anthracoceros albirostris*
Great hornbill	*Buceros bicornis*
Common hoopoe	*Upupa epops*
Red headed trogon	*Harpactes erythrocephalus*
Indian Roller	*Coracias benghalensis*
Common Kingfisher	*Alcedo atthis*
White-throated kingfisher	*Halcyon smyrnensis*
Pied kingfisher	*Ceryle rudis*
Green bee-eater	*Merops orientalis*
Chestnut-headed bee-eater	*Merops leschenaulti*
Pied cuckoo	*Clamator jacobinus*
Common hawk cuckoo	*Hierococcyx varius*
Hodgson's hawk cuckoo	*Hierococcyx fugax*
Indian cuckoo	*Cuculus micropterus*
Banded bay cuckoo	*Cacomantis sonneratii*
Grey-bellied cuckoo	*Cacomantis passerinus*
Asian koel	*Eudynamys scolopacea*
Sirkeer Malkoha	*Phaenicophaeus leschenaultii*
Greater coucal	*Centropus sinensis*
Lesser coucal	*Centropus benghalensis*
Alexandrine parakeet	*Psittacula eupatria*
Rose-ringed parakeet	*Psittacula krameri*
Plum-headed parakeet	*Psittacula cyanocephala*
House swift	*Apus affinis*
Crested treeswift	*Hemprocne coronata*
Barn owl	*Tyto alba*
Grass owl	*Tyto capensis*
Collared scops owl	*Otus bakkamoena*
Eurasian eagle owl	*Bubo bubo*
Dusky eagle owl	*Bubo coromandus*
Brown fish owl	*Ketupa zeylonensis*
Jungle owlet	*Glaucidium radiatum*
Spotted owlet	*Athene brama*
Short-eared owl	*Asio flammeus*
Grey nightjar	*Caprimulgus indicus*
Large-tailed nightjar	*Caprimulgus macrurus*
Indian nightjar	*Caprimulgus asiaticus*
Savanna nightjar	*Caprmulgus affinis*
Rock pigeon	*Columba livia*
Yellow-eyed pigeon	*Columba eversmanni*

Oriental turtle dove	*Streptopelia orientalis*
Laughing dove	*Streptopelia senegalensis*
Spotted dove	*Streptopelia chinensis*
Red collared dove	*Streptopelia tranquebarica*
Eurasian collared dove	*Streptopelia decaocto*
Emerald dove	*Chalcophaps indica*
Orange-breasted green pigeon	*Treron bicincta*
Pompadour green pigeon	*Treron pompadora*
Yellow-footed green pigeon	*Treron phoenicoptera*
Pin-tailed green pigeon	*Treron apicauda*
Wedge-tailed green pigeon	*Treron sphenura*
Water rail	*Rallus aquaticus*
Brown crake	*Amaurornis akool*
White-breasted waterhen	*Amaurornis phoenicurus*
Little crake	*Porzana parva*
Ruddy-breasted crake	*Porzana fusca*
Spotted crake	*Porzana porzana*
Watercock	*Gallicrex cinerea*
Purple swamphen	*Porphyrio porphyrio*
Common moorhen	*Gallinula chloropus*
Common coot	*Fulica atra*
Common snipe	*Gallinago gallinago*
Marsh sandpiper	*Tringa stagnatilis*
Common greenshank	*Tringa nebularia*
Green sandpiper	*Tringa ochropus*
Wood sandpiper	*Tringa glareola*
Greater painted-snipe	*Rostratula benghalensis*
Eurasian thick-knee	*Burhinus oedicnemus*
Black-winged stilt	*Himantopus himantopus*
Pheasant-tailed jacana	*Hydrophasianus chirurgus*
Bronze-winged jacana	*Metopidius indicus*
Pacific golden plover	*Pluvialis fulva*
Red-wattled lapwing	*Vanellus indicus*
White-tailed lapwing	*Vanellus leucurus*
River tern	*Sterna aurantia*
Black-bellied tern	*Sterna acuticauda*
Osprey	*Pandion haliaetus*
Black kite	*Milvus migrans*
Brahminy kite	*Haliastur indus*
Egyptian vulture	*Neophron percnopterus*
White-rumped vulture	*Gyps bengalensis*
Long-billed vulture	*Gyps indicus*

Crested serpent eagle	*Spilornis minimus*
Eurasian marsh harrier	*Circus aeruginosus*
Shikra	*Accipiter badius*
Oriental honey-buzzard	*Pernis ptilorhyncus*
White-eyed buzzard	*Bustastur teesa*
Changeable hawk eagle	*Spizaetus cirrhatus*
Little grebe	*Tachybaptus ruficollis*
Darter	*Anhinga melanogaster*
Little cormorant	*Phalacrocorax pygmeus*
Indian cormorant	*Phalacrocorax fuscicollis*
Great cormorant	*Phalacrocorax carbo*
Little egret	*Egretta garzetta*
Great egret	*Casmerodius albus*
Intermediate egret	*Mesophoyx intermedia*
Cattle egret	*Bubulcus ibis*
Indian pond heron	*Ardeola grayii*
Grey heron	*Ardea cinerea*
Purple heron	*Ardea purpurea*
Black-crowned night heron	*Nycticorax nycticorax*
Yellow bittern	*Ixobrychus sinensis*
Cinnamon bittern	*Ixobrychus cinnamomeus*
Painted stork	*Mycteria leucocephala*
Asian openbill	*Anastomus oscitans*
Woolly-necked stork	*Ciconia episcopus*
White stork	*Ciconia ciconia*
Oriental stork	*Ciconia boyciana*
Black-necked stork	*Ephippiorhynchus asiaticus*
Lesser adjutant	*Leptoptilos javanicus*
Indian pitta	*Pitta brachyura*
Orange-bellied leafbird	*Chloropsis hardwickii*
Bay-backed shrike	*Lanius vittatus*
Long-tailed shrike	*Lanius schach*
Rufous treepie	*Dendrocitta vagabunda*
House crow	*Corvus splendens*
Large-billed crow	*Corvus macrorhynchos*
Eurasian golden oriole	*Oriolus oriolus*
Black-hooded oriole	*Oriolus xanthornus*
Small minivet	*Pericrocotus cinnamomeus*
Scarlet minivet	*Pericrocotus flammeus*
Whit-browed fantail	*Rhipidura aureola*
Black drongo	*Dicrurus macrocercus*
White-bellied drongo	*Dicrurus caerulescens*

Spangled drongo	*Dicrurus hottentottus*
Greater racket-tailed drongo	*Dicrurus paradiseus*
Black-naped monarch	*Hypothymis azurea*
Asian paradise-flycatcher	*Terpsiphone paradisi*
Common Iora	*Aegithina tiphia*
Common woodshrike	*Tephrodornis pondicerianus*
Orange-headed thrush	*Zoothera citrina*
Dark-throated thrush	*Turdus ruficollis*
Grey-headed canary flycatcher	*Culicicapa ceylonensis*
White-tailed rubythroat	*Luscinia pectoralis*
Bluethroat	*Luscinia svecica*
Oriental magpie robin	*Copsychus saularis*
White-rumped shama	*Copsychus saularis*
Indian Robin	*Saxicoloides fulicata*
Black redstart	*Phoenicurus ochruros*
Common redstart	*Phoenicurus phoenicurus*
Common stonechat	*Saxicola torquata*
White-tailed stonechat	*Saxicola leucura*
Pied bushchat	*Saxicola caprata*
Grey bushchat	*Saxicola ferrea*
Chestnut-tailed starling	*Sturnus malabaricus*
Brahminy starling	*Sturnus pagodarum*
Asian pied starling	*Sturnus contra*
Common myna	*Acridotheres tristis*
Bank myna	*Acridotheres ginginianus*
Chestnut-bellied nuthatch	*Sitta castanea*
Great tit	*Parus major*
Plain martin	*Riparia paludicola*
Red-rumped swallow	*Hirundo daurica*
Northern house martin	*Delichon urbica*
Black-crested bulbul	*Pycnonotus melanicterus*
Himalayan bulbul	*Pycnonotus leucogenys*
Red-vented bulbul	*Pycnonotus cafer*
Grey-breasted prinia	*Prinia hodgsonii*
Yellow-bellied prinia	*Prinia flaviventris*
Ashy prinia	*Prinia socialis*
Zitting cisticola	*Cisticola juncidis*
Bright-headed cisticola	*Cisticola exilis*
Oriental white-eye	*Zosterops palpebrosus*
Clamorous reed warbler	*Acrocephalus stentoreus*
Striated grassbird	*Megalurus palustris*
Rufous-rumped grassbird	*Graminicola bengalensis*

Tawny-bellied babbler	*Dumetia hyperythra*
Chestnut-capped babbler	*Timalia pileata*
Yellow eyed babbler	*Chrysomma sinense*
Jerdon's babbler	*Chrysomma altirostre*
Spiny babbler	*Turdoides nipalensis*
Common babbler	*Turdoides caudatus*
Striated babbler	*Turdoides earlei*
Jungle babbler	*Turdoides striatus*
Yellow-billed babbler	*Turdoides affinis*
Singing bushlark	*Mirafra cantillans*
Ashy-crowned sparrow lark	*Eremopterix nigriceps*
Rufous-tailed lark	*Ammomanes phoenicurus*
Eurasian skylark	*Alauda arvensis*
Oriental skylark	*Alauda gulgula*
Purple sunbird	*Nectarinia asiatica*
Crimson sunbird	*Aethopyga siparaja*
Little spiderhunter	*Arachnothera longirostra*
House sparrow	*Passer domesticus*
Spanish sparrow	*Passer hispaniolensis*
Chestnut-shouldered petronia	*Petronia xanthocollis*
White wagtail	*Motacilla alba*
White-browed wagtail	*Motacilla maderaspatensis*
Citrine wagtail	*Motacilla citreola*
Yellow wagtail	*Motacilla flava*
Grey wagtail	*Motacilla cinerea*
Richard's pipit	*Anthus richardi*
Paddyfield pipit	*Anthius rufulus*
Blyth's pipit	*Anthus godlewskii*
Red-throated pipit	*Anthus cervinus*
Rosy pipit	*Anthus roseatus*
Water pipit	*Anthus spinoletta*
Buff-bellied pipit	*Anthus rubescens*
Black-throated accentor	*Prunella atrogularis*
Black-breasted weaver	*Ploceus benghalensis*
Striated weaver	*Ploceus manyar*
Baya weaver	*Ploceus philippinus*
Finn's weaver	*Ploceus megarhynchus*
Red avadavat	*Amandava amandava*
Scaly-breasted munia	*Lonchura punctulata*
Brambling	*Fringilla montifringilla*
Yellow-breasted greenfinch	*Carduelis spinoides*
Spectacled finch	*Callacanthis burtoni*

Common rosefinch	*Carpodacus erythrinus*
Brown bullfinch	*Pyrrhula nipalensis*
Red-headed bullfinch	*Pyrrhula erythrocephala*
Collared grosbeak	*Mycerobas affinis*
Spot-winged grosbeak	*Mycerobas melanozanthos*
Crested bunting	*Melophus lathami*
White-capped bunting	*Emberiza stewarti*
Little bunting	*Emberiza pusilla*
Black-headed bunting	*Emberiza melanocephala*
Black-faced bunting	*Emberiza spodocephala*
Reed bunting	*Emberiza schoeniclus*
Corn bunting	*Miliaria calandra*

APPENDIX 3: SOME COMMON REPTILES OF JJCR

Common Name	Scientific name
Marsh Crocodile	*Crocodylus palustris*
Gharial	*Gavialis gangeticus*
Indian Pond Terrapin	*Melanochelys trijuga*
Indian Sawback	*Kachuga tecta*
Three-striped Roofed Terrapin	*Kachuga dhongoka*
Red Crowned Roofed Terrapin	*Kachuga kachuga*
Brahminy Terrapin	*Hardella thurjii*
Spotted Black Terrapin	*Geoclemys hamiltonii*
Indian Mud Turtle	*Lissemys punctata*
Chitra Turtle	*Chitra indica*
Northern House Gecko	*Hemidactylus flaviviridis*
Bark Gecko	*Hemidactylus leschenaultii*
Brook's Gecko	*Hemidactylus brookii*
Termite Hill Gecko	*Hemidactylus triedrus*
Rock Gecko	*Hemidactylus maculatus*
Common garden lizard	*Calotes versicolor*
Indian Chameleon	*Chamaeleon zeylanicus*
Common skink	*Mabuya carinata*
Little skink	*Mabuya macularia*
Snake skink	*Lygosoma punctatus*
Common Indian monitor	*Varanus bengalensis*
Yellow monitor	*Varanus flavescens*
Blind snake	*Ramphotyphlops braminus*
Beaked blind snake	*Rhinotyphlops acutus*
Russell's earth boa	*Eryx conicus*
John's earth boa	*Eryx johnii*
Indian python	*Python molurus*
Trinket snake	*Elaphe helena*
Common rat snake	*Ptyas mucosus*
Gray's rat snake	*Argyrogena ventromaculatus*
Common kukri snake	*Oligodon arnensis*
Painted bronze back	*Dendrelaphis pictus*
Gliding snake	*Chrysopelea ornata*
Common wolf snake	*Lycodon aulicus*
Shaw's wolf snake	*Lycodon striatus*
Checkered keelback	*Xenochrophis piscator*
Buffstriped keelback	*Amphiesma stolata*
Olivaceous keelback	*Atretium schistosum*
Cat snake	*Boiga trigonata*
Schneider's smooth water snake	*Enhydris enhydris*
Common Indian krait	*Bungarus caeruleus*
Indian cobra	*Naja naja*
King cobra	*Ophiophagus hannah*
Russell's viper	*Daboia russelii*

APPENDIX 4: SOME COMMON MAMMALS OF JJCR

Common Name	**Scientific name**
Rhesus Macaque	*Macaca mulatta*
Hanuman langur	*Semnopithecus entellus*
Sambar	*Cervus unicolor*
Swamp Deer	*Cervus duvaucelii*
Indian Muntjac	*Muntiacus muntjak*
Hog Deer	*Axis porcinus*
Spotted Deer	*Axis axis*
Nilgai	*Boselaphus tragocamelus*
Wild Pig	*Sus scrofa*
Asian Elephant	*Elephas maximus*
Jackal	*Canis aureus*
Tiger	*Panthera tigris*
Common Leopard	*Panthera pardus*
Jungle Cat	*Felis chaus*
Smooth-Coated Otter	*Lutrogale perspicillata*
Marten	*Martes flavigula*
Small Indian Civet	*Viverricula indica*
Large Indian Civet	*Viverra zibetha*
Common Palm Civet	*Paradoxurus hermaphroditus*
Grey Mongoose	*Herpestes edwardsii*
Small Indian Mongoose	*Herpestes javanicus*
Ruddy Mongoose	*Herpestes smithii*
Indian Hare	*Lepus nigricollis*
House Shrew	*Suncus murinus*
Pygmy Shrew	*Suncus etruscus*
Grey Woodland Shrew	*Crocidura attenuata*
Indian Porcupine	*Hystrix indica*
Five striped palm squirrel	*Funambulus pennantii*
Large Bandicoot-Rat	*Bandicota indica*
Lesser Bandicoot-Rat	*Bandicota bengalensis*
Short-tailed Bandicoot-Rat	*Nesokia indica*
House Rat	*Rattus rattus*
Soft-furred Field Rat	*Millardia meltada*
Indian Bush Rat	*Golunda ellioti*
House Mouse	*Mus musculus*
Little Indian Field mouse	*Mus booduga*
Spiny field mouse	*Mus platythrix*
Indian Flying fox	*Pteropus giganteus*
Fulvous fruit bat	*Rousettus leschenaulti*

APPENDIX 5: SOME COMMON AMPHIBIANS OF JJCR

Common Name	**Scientific name**
Common Indian toad	*Bufo melanostictus*
Common tree frog	*Polypedates maculatus*
Skittering frog	*Euphlyctis cyanophlyctis*
Indian pond frog	*Euphlyctis hexadactylus*
Indian bull frog	*Hoplobatrachus tigerinus*
Jerdon's bull frog	*Hoplobatrachus crassus*
Indian burrowing frog	*Sphaerotheca breviceps*

APPENDIX 6: SOME COMMON BUTTERFLIES OF JJCR

Family - Lycaenidae
Common Grass Blue
Common Guava Blue
Common Hedge Blue
Common Pierrot
Metallic Caerulean
Peacock Royal
Yamfly
Family - Nymphalidae
Blue Pansy
Common Bush Brown
Common Castor
Common Five Ring
Common Indian Crow
Cruiser
Great Eggfly
Grey Pansy
Orange Oakleaf
Peacock Pansy
Plain Tiger
Striped Blue Crow
Tawny Rajah
Yellow Coster
Family - Papilionidae
Common Mormon
Family - Pieridae
Brown Veined White
Common Grass Yellow
Crimson Tip
Great Orange Tip
Pioneer
Psyche
Yellow Orange Tip